Picatinny Arsenal
One mile north of Route 80
Dover Vicinity
Morris County
New Jersey

HAER No. NJ-36

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DRAWINGS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

PHOTOGRAPHS

Historic American Engineering Record
National Park Service
Department of the Interior
Washington, D.C. 20240

Picatinny Arsenal

HISTORIC AMERICAN ENGINEERING RECORD

NJ-36

Location:	One mile north of I-80 on State Route 15 north of Dover, New Jersey
Date of Construction:	1880 through 1980s
Owner:	Department of the Army
Significance:	Originally built as a depot for the storage of powder and other armaments, in the 20th century Picatinny Arsenal became a leading facility for the research and development and production of munitions. Following a catastrophic accident in July 1926, when a large portion of the site was destroyed by a lightning-ignited explosion, this Federal reservation was rebuilt. With the outbreak of World War II, Picatinny Arsenal became a major supplier of munition to Allied Forces and, more importantly, provided plans and personnel training required in the construction and operation of other munition facilities. During the Korean and Vietnam conflicts, Picatinny Arsenal remained active in both production engineering and research.
Historical Report Prepared by:	Pamela Thurber, 1982; Sandy Norman, 1983
Report Prepared for Transmittal by:	Donald C. Jackson and Robie S. Lange, 1984

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Introduction and Acknowledgments

During the summer of 1982, the Historic American Engineering Record (HAER), with the financial support of the US Army Material Development and Readiness Command (DARCOM), inventoried five DARCOM installations (Watertown Arsenal, MA; Aberdeen Proving Ground, MD; Savanna Army Depot, IL; Kansas Army Ammunition Plant, KS; and Picatinny Arsenal, NJ). These pilot inventories field tested procedures that would be used for future historic resource inventories by a non-government contractor for DARCOM's 69 remaining installations. At Picatinny Arsenal this inventory work also produced an overview of its history, which provided substantial information on the development of the installation.

As a result of the 1982 work, HAER received funding from Picatinny Arsenal to more fully document historically significant structures and industrial processes at the site. Undertaken in 1983, this documentation focused on five areas of the arsenal:

1) 200 AREA: Shell Component Loading District
2) 400 AREA: Gun Bag Loading District
3) 500 AREA: Powder Factory and Power House District
4) 600 AREA: Test Areas District
5) 800 AREA: Complete Rounds/Melt Loading District

These studies included written and photographic documentation, measured drawings of buildings and site plans, and interpretive drawings of material handling techniques and chemical processes used in the production of explosives.

The 1982 team was under the direction of Pamela Thurber, Field Supervisor, and consisted of David Buchanan and Deborah Wolf, Architectural Historians, and David Ashby and John Mecum, Architect Technicians. The 1983 team consisted of Sandy Norman, Supervisory Historian, and Len Kliwinski and Ken Grabowski, Architect Technicians.

Nicholas J. Mergel, Chief of the Environmental Office, and Frances J. Grego of his staff served as HAER's official point of contact for both summer teams and helped coordinate work with numerous other individuals whose assistance was of great value. Those individuals who assisted the HAER project included: Robert Aikens, Ronald Bailey, Domenic Bizzari, Duane Chorey, Robert Cruthers, Patrick Cunningham, Richard Drew, Ray Hajducsek, William Huffman, Alvis Lewis, Clifford Love, Luther Martin, John McDonough, Manny Meyers, Clare Nugent, Clifford Redden, Louis Rigassio, Donald Snyder, William Sweeney, Frank J. Van Fleet, and Samuel Zarra. Without their help, the preparation of this report would not have been possible.

HISTORICAL OVERVIEW

Picatinny Arsenal occupies approximately 6,500 acres in a valley bordered by Picatinny Peak and centered by Lake Picatinny in Rockaway Township, New Jersey. The site was established by the Department of War as the Dover Powder Depot in September 1880 (later known as Picatinny Powder Depot and the US Powder Depot). In 1891, 315 acres of property were ceded to build a naval powder depot.

During the first decade of this century, temporary facilities were begun for explosive loading and projectile filling plants, and later a smokeless powder production facility was established. During and following World War I, the arsenal earned a reputation as the Army's authority on the manufacturing of ammunition. The installation contains over 1,500 buildings, approximately 25% of which are storage facilities and another 25% of which are designated for research, development and testing. Most of the buildings at Picatinny were constructed during the 1930s and 1940s to replace those destroyed by a accidental series of explosions at the adjacent Lake Denmark Naval Powder Depot on July 10, 1926.

A positive side effect of the 1926 Explosion was that by World War II Picatinny Arsenal was operating with new facilities and was capable of coping with wartime demands. In addition to its role as manufacturer, Picatinny Arsenal also provided technical information, guidance and training to private industry which produced ammunition to satisfy wartime requirements. Following the war, Picatinny maintained production capabilities utilized during the Korean and Vietnam conflicts. Simultaneously, the Arsenal continued to develop and test new conventional and nuclear weapons systems.

Pre-Arsenal History

The site of Picatinny Arsenal has a history of munitions manufacturing dating from colonial times. In 1749, the Middle Forge, located at the foot of Picatinny Peak on the southern end of Lake Picatinny, was established by Jonathan Osborne. In 1772, Colonel John Ford, owner of the black powder mills in nearby Morristown, acquired the forge and later deeded it to his son John Ford, Jr. John Jacob Faesch, a Swiss immigrant and master iron worker, then leased the forge from the Ford family and acquired it upon John Ford Jr.'s death in 1778. During the Revolutionary War, Faesch provided the Continental Army with bar iron, cannon, shot, shovels, axes and other iron implements. George Washington reputedly visited the Mount Hope Ironworks, which included the Middle Forge, during the war and definitely provided Faesch with Hessian prisoners to assist in its operations.[1]

Following the war, Faesch became a prominent member of the community serving as Morris County delegate to the New Jersey State Convention which ratified the Federal Constitution.[2] Upon his death in 1799, the Mount Hope Ironworks and other extensive iron properties passed into his sons' hands. They were unable to run the works profitably and sold them in 1809. Moses Phillips purchased the Mount Hope Ironworks and operated it as the Aetna Forge until 1839, when Jacob Righter became owner.[3] Upon his death in 1853, the complex was left to his son, George E. Righter, who sold the property to the Federal Government in 1879. The early 19th century iron industry in New Jersey was a profitable one. The period from 1804 to 1816 was prosperous, but there came a depression in 1820. The decade from 1830 to 1840 was again profitable due primarily to a technological change in 1837 that introduced the hot blast process. However a stone coal manufacturing process led to the ultimate demise of the iron industry in the Northeastern United States. At the height of its operation, the ironworks reportedly employed 60 men and produced 10-20 tons of the iron per week. The forge trip hammer, weighing 600 pounds, and the anvil, two feet square and weighing some 4,000 pounds, along with other tools are on exhibit at Picatinny Arsenal.[4]

Purchase of the Tract by the US Government

The history of public involvement at the Picatinny site begins with the changes in military preparedness as a result of the Civil War. As early as 1862, the Chief of Ordnance had urged the army to begin construction of a "Grand Arsenal" on the Atlantic seaboard. In 1866, a Board of Governors was convened by the Ordnance Department to consider the establishment and location of two powder depots on the East Coast. The requirements of the board included: (1) that the region selected be sparsely populated; (2) that the capability exist to store a large amount of powder in a location near New York City; and (3) that the site chosen be accessible to rail transportation.[5] In 1875, legislation was passed by Congress urging the Secretary of War to examine the arsenals east of the Mississippi River and report on the number that could be closed and sold. The Sundry Civil Bill of March 1875 included this directive:

> "The Secretary of War is hereby directed to cause an examination to be made into the condition of the United States Arsenals east of the Mississippi River; and report to the next Congress how many of the same can be sold without interfering with the necessities of the military service, together with an estimate of the amount that can probably be realized from the sale of each of the same whenever such sale shall be directed by Congress.[6]

The Board of Governors which convened as a result of this directive recommended that the Watertown, Watervliet, Pikeville, Washington, Allegheny, Columbus, and Detroit Arsenals be sold, and a Grand Arsenal, to include a proving ground and powder depot, be built with the proceeds.

An Ordnance Department committee, headed by Lt. Col. Silas Crispin, was appointed in March 1875 to determine the location for a Grand Arsenal. In 1879, $50,000 was appropriated for the purchase of land for a powder depot. Maj. Francis H. Parker of the Ordnance Department was ordered to examine potential sites and in July 1879, he personally inspected land near Dover, NJ; Bricksburg, NJ; Cornwall, NJ; Ellenville, NY; Rosendale, NY; Sloatsburg, NY; Cold Springs, NY; and West Point, NY. These locations had in common rural seclusion, proximity to New York City, and convenient access to transportation networks.[7]

A second committee of the Board of Governors convened in October 1879 to choose and purchase a site for the Army's Grand Arsenal on the East Coast. This board included Lt. Silas Crispin, Maj. F.H. Parker and T.G. Baylor. Based on Parker's findings, the Board selected a site near Peekskill, NY, and instructed Parker to inquire about its purchase. Though ideally suited for the Army's purposes, the cost of the Peekskill tract was prohibitive.[8] On February 9, 1880, pressed to find a site by the end of the fiscal year, the Board recommended a tract in Queensboro, NY. However, acquisition again proved difficult. On February 26, the Dover, NJ, site was suggested though there was some question of its security from coastal invasion.[9] Brigadier General Stephen Vincent Benet, Chief of Ordnance, quelled these concerns by personally endorsing the Dover site:

> "The geographic location near Dover is sufficiently well protected, being behind the fortification of N.Y. Harbor, nestling high among the mountains, 45 miles distant, with a closely built and highly cultivated country, and very large population intervening."[10]

The Ordnance Board completed arrangements for the purchase and 1,866.12 acres was acquired by the government for $62,750, or about $30 per acre:

Date of Purchase	From Whom Purchased	Area	Amount
September 4, 1880	George E. Righter	1,195.80	$35,874
September 8, 1880	W. H. Wiggins	167.32	$ 8,500
November 17, 1880	Edward C. Fieldler	304.20	$ 9,126
February 7, 1881	Henry and Michael Doland	11.00	$ 750
April 20, 1881	John E. Kindred	187.80	$ 8,500

A strip of land to be used as a roadway was bought from Louis H. Spicer on May 2, 1881. Leading from Spicertown, an unincorporated village in Rockaway

Township, to the depot grounds, the parcel, 50 feet wide and 7,412 feet long, added about 8.5 acres to the site.

The decision to locate a Army installation in the rural area of northern New Jersey was a significant event in the development of Morris County. The Morris County weekly, The Jerseyman, reporting on the occasion of the purchase, noted that "the improvements and changes, together with the appearance of United States officers and soldiers, will make a great change in that part of the county."[11]

Construction for Powder Storage: 1880-1890

The new depot's first decade witnessed construction of storage magazines, officers' quarters, stables and service buildings. The first structure, a powder magazine measuring 200 x 50 feet with a six foot basement, was started on September 16, 1880 and completed in 1881 at a cost of $51,700. It was designed to store 10,000 lbs. of black powder. Piers and foundations were of stone quarried at the site. Yellow pine flooring was supported on brick arches spanning heavy wrought-irons beams leveled with concrete. The ceiling, supported by a row of cast-iron columns down the center of the building, consisted of brick arches and wrought-iron I-beams with roof trusses of wrought iron.[12] The magazine was reported to contain 200,000 lbs. of iron, 450,000 bricks, and 14,000 cubic feet of granite in the piers, foundations and lintels.[13]

By early 1882, the 150 men employed at the depot were primarily engaged in stone quarrying and building construction. In May 1882, however, the original government appropriation was depleted and the remaining workers, only 22 men, were engaged in farming the land.[14] A second appropriation, in the summer of 1882, allowed construction to continue. By June 1883, a work force of 75 men was finishing work on the second powder magazine which was completed by the end of 1883.[15] The third and fourth magazines and an office were completed in 1885, while the fifth "original" magazine was not completed until 1890.[16] Ordnance Department Chief Brig. Gen. Benet approved the first plan for the Picatinny Powder Depot in 1885. This plan included 11 storage magazines, a stable, foreman's quarters, an office, an engine house, a store, a shop and other sites planned for future buildings.

The Cannon Gates were installed in October 1885 to provide the new installation with an appropriate entrance. The Gates, constructed by the Cornell Iron Works, was patterned from a special design which used heavy cannon mounted on stone foundations to serve as posts for the wrought-iron gates. The gates themselves were decorative wrought-iron, embellished with the insignia of the Ordnance Department. The Dover Era, praised the new work as "a very artistic and imposing entrance."[18] The first shipment of powder, 300,000 lbs. of a hexagonal type, was sent to the depot for storage in November 1886.[17]

By June 1887, 23.5 miles of track connecting the Army depot with the Delaware Lackawanna and Western Railroad and the Dover and Central Railroad of New

Jersey at Wharton had been laid by the Morris County Railroad Company of New Jersey under the terms of a 9-acre right-of-way granted by a 99-year lease.[19] In July 1887, 70 men were employed at the depot and 900,000 pounds of powder were in storage.[20] In 1889, it was announced that 4,500 tons of saltpeter used in the production of black powder were to be stored there.[21]

Establishment of the Navy's Lake Denmark Powder Depot, 1891.

In 1890, the Department of the Navy transferred its powder magazine on Ellis Island in New York Harbor to the Treasury Department. This left the Navy without an adequate powder storage facility on the East Coast. By act of Congress, approved April 11, 1890, $75,000 was appropriated to purchase a new site for a powder depot.[22] The site selected was located at Lake Denmark, New Jersey, and was part of the Army's Picatinny Powder Depot. Lake Denmark was chosen for many of the same reasons that attracted the Ordnance Department and title for 315 acres was formally ceded to the Navy on June 9, 1891. Ground was immediately cleared for construction.[23]

The Lake Denmark Powder Depot was the Navy's principle East Coast facility and was intended to be the general storage depot for all powder and high explosives.[24] The first structures, a magazine for the storage of powder and explosives, a shell house, and three small frame houses for Navy caretaker personnel, were completed in 1892, by a local contractor, J. J. Vreeland, who had also worked for the Army at the site.[25] By 1894, the depot also included three large buildings for the storage of powder and ammunition, two smaller structures for the storage of high explosives and one large building for loading artillery shells.

The early history of Lake Denmark is one of gradual but steady expansion. The Spanish-American War (1898-1899) and the growing needs of the Navy contributed to the development of the facility. Two additional tracts of land were acquired in 1902 - a parcel of 78.58 acres by purchase and a second tract of 67.5 acres, confiscated by Presidential proclamation.[26]

America's involvement in World War I (1917-1918) placed increased demands on the powder storage facilities of the East Coast. After the war, an overload of ammunition created new demands for powder and high explosives storage facilities. To meet these needs, new storage magazines were constructed at the Lake Denmark Powder Depot to accommodate the increased demands and burdens of a rapid national development.[27]

Early Projectile Loading: 1897-1906

Several small-scale loading operations were begun at the depot in the late 19th and early 20th centuries. The assembly of powder charges for cannon began on the Army post in 1897. This process involved the manufacture of silk cartridge bags to contain the powder charge and the filling of charges for separately loaded ammunition. As a result, buildings for the storage of loaded projectiles and explosives were required. By 1902, six magazines for the storage of sodium nitrate and filled projectiles had been constructed.

A temporary plant for loading armor-piercing projectiles with Maximite, including a boiler house and a loading house, was constructed in 1903. Several thousand projectiles were manually filled and compressed before Explosive "D" completely supplanted Maximite. The shells which had been loaded with Maximite were unloaded in 1906-7.[28] A plant for loading shells with Explosive "D" was completed in 1904 and continued in operation until 1906 when a policy of loading projectiles in the field was instituted.[29]

The expansion of operations at the Army post required construction of new service buildings and laboratories. By 1906, a water powered wheel and dynamo house was constructed at the southwestern corner of Lake Picatinny; a metal working shop was built; and a building in which to assemble fixed ammunition was constructed. However, plans for this activity were abandoned and the building was converted to a chemical laboratory and later to a high explosives plant. By 1906, there were 105 buildings on the Army base.

Early Production Phase: World War I (1906-1918)

Congress passed the fortification bill on June 25, 1906 authorizing $165,000 to build and equip a major powder manufacturing site for the Army. A Board of Officers, consisting of Lt. Col. Roger Birnie, Major Beverly W. Dunn and Major Odus C. Horney, was appointed to select a site for the factory. The board reviewed Fort Montgomery near West Point, Rock Island Arsenal, St. Louis Arsenal, and the United States Powder Depot as possible locations. The Chief of Ordnance recommended the New Jersey site to the Secretary of War. In 1907, this location was chosen as the first Army-owned smokeless powder plant.[30] In October 1907, the installation's name was officially changed to "Picatinny Arsenal."

Major Dunn, the inventor of Explosive "D," was detailed to supervise building the powder factory on May 14, 1907. Dunn prepared the plans, but left shortly thereafter for a position with the American Railway Association. Work on the powder factory began in April, 1907 under Major Horney, who was given command of the post on June 10, 1907.[31] The buildings were completed in eight months and the manufacture of cannon powder begun in January 1908. The plant had an initial production capacity of 3,000 pounds of powder daily. This facility differed from other powder factories in the United States because it employed the Thompson displacement process in the nitration of cotton.[32] This process was later replaced by the Dupont Centrifugal Wringer Process.

In 1908, equipment for the manufacture of powder for small arms of .30 caliber was installed. The original capacity of this plant was 250 to 300 pounds of small arms powder per day.[33]

In 1909, Picatinny became solely responsible for the assembly of fixed ammunition above .50 caliber. On Mareh 4, 1909, Congress approved $175,000 for the expansion of its powder factory. Production capacity increased to 9,000 pounds of smokeless powder daily.[34]

In 1911, Congress authorized the expenditure of $20,000 was obtained construction of a plant to manufacture Explosive "D," an explosive used as a bursting charge in armor-piercing projectiles.[35] This plant was in operation by 1913 with a daily production capacity of 1,000 pounds.[36] It remained operational until 1918, when the factory was dismantled.[37]

In November 1911, an Officer's Training School was established to provide instruction in the chemistry of explosives and ballistics. Training was in the ammunition manufacturing process and War Department methods.[38] By 1913, employment at Picatinny stood at 200. In 1914, 124 buildings were located on the site.

With the entry of America into World War I, there was a need for additional storage capability for powder and other ordnance materials. Fifty-four new storage buildings, a new powder house, a locomotive round house, garages and more office space were constructed. More roads were planned and new railroad right of ways were established. During the war the Arsenal hired 2,600 workers to meet war time production needs.

The post's most significant role during World War I was not the manufacture or loading of projectiles, since private firms (Dupont, Hercules, Aetna, and

Atlas Powder) received contracts from the Army to produce the bulk of explosives. Rather, Picatinny Arsenal served as an important munitions training and research center and provided a liaison between the Army and private industry. The work accomplished during World War I established Picatinny Arsenal as an important research installation, and helped insure it a significant post-war role.

Early Experimental Phase: 1918-1926

After the Armistice in November 1918, the production of powder was halted and the arsenal served as a field depot for one year for the storage of surplus powder. Employment declined from 2,600 to 1,300; by 1919-20 it dropped further to between 600 and 1,000. However activities soon accelerated as a plant for manufacturing pyrotechnic flares and signals was established and a small experimental plant for artillery ammunition was begun.

Major developments soon began that would sustain the post between the wars and establish Picatinny Arsenal as the major center for explosives research and development. The Ordnance Department decreed on December 28, 1920 that it would be a complete ammunition arsenal. An intensive building and renovation program was launched and all the Army's research on fuzes was transferred to the site. Nine buildings were constructed for drying, grinding and sieving explosives such as dicyandiamid, quaridine nitrate and pentaerythrite. Storage tanks for raw materials and a control laboratory were also constructed.[39] Plants were established for loading TNT and Amatol into bombs and shells and to load fuzes and assemble complete rounds. Fifty buildings, including the powder factory, were renovated for new experimental work. To support these expanded facilities, the physical plant was modernized to include new steam, electric and sewage lines and the power house was refitted with new boilers and generators. By 1922, Picatinny Arsenal contained 485 buildings.[40]

Explosion At Lake Denmark Powder Depot, July 10, 1926

Around 5:15 on the afternoon of Saturday, July 10, 1926, a severe electrical storm hit the Dover area and lightning struck the southwest end of the Naval Powder Depot. Attempts to contain the resulting fire proved futile. At 5:20, a tremendous explosion outside temporary Magazine No. 8 caused considerable damage to it and other magazines in the vicinity, thus exposing their contents to flame and shrapnel. As a result, fires spread rapidly and a series of sympathetic explosions occurred throughout the area. At about 5:25, the contents of Storehouse No. 9, 150 feet distant from Storehouse No. 8, exploded.[41]

Temporary Storehouses No. 8 and 9 were of typical storehouse construction: one story hollow clay tile and brick buildings with steel roof trusses. Roofs were wood with tar sheeting. Both buildings were equipped with lightning rods. Temporary Storehouse No. 9 held 1,600,000 lbs. of TNT stored in boxes. Storehouse No. 8 contained an estimated 670,000 lbs. of various types of explosives from depth charges to bomb fuzes. A third explosion leveled Shell Storehouse No. 22 which contained 180,000 lbs. of loaded artillery shells and fuzes. Fortunately, 2,500,000 lbs. of Explosive "D" stored in Storehouse No. 11 (500 feet from the blast area) burned rather than detonated thus avoiding another major explosion.[42]

The detonations triggered tremendous shock waves and caused a series of destructive reverberations. Everything within a 3000 foot radius of the blasts was destroyed. Beyond 3,000 feet, many buildings in the Naval depot were seriously damaged.[43] Steel structural members were twisted and bent by the pressure waves, tile walls were pulled down by falling steel trusses, and many fragments were sent flying by the blast. Brick walls often remained standing, but generally were fractured and left structurally unsound. None of the Navy's 160 buildings was untouched by the tremendous force of the explosion.

The explosion also did considerable damage to buildings at Picatinny Arsenal because of its location in the valley directly below the Navy's depot. This included many buildings associated with the Nitrocellulose Smokeless Powder Plant. The two-story Boiling Tub House (distance 1,250 feet) and the Poaching House (distance 1,400 feet) were completely destroyed. The Ether/Alcohol Building's steel frame (distance 1,650 feet) was not structurally damaged, though all the iron siding was blown off and the Dehydration, Mixing, and Pressing Building (distance 1,900 feet) suffered damage to its steel structure and tile walls, though the concrete partition walls remained standing.[44]

The explosion damaged many important production buildings within 2,000-3,000 feet of the blasts. Among these were the Tetryl Manufacturing Building (distance 2,050 feet), the TNT Purification Building (distance 2,200 feet), and the Ammonium Picrate Purification Building (distance 2,250 feet). Because of their reinforced concrete frame these buildings did not collapse, but their tile infill walls and windows were heavily damaged.

A number of storehouse buildings (2,300 feet distance) were demolished by the force of the explosion. These buildings were generally constructed on concrete foundations with brick or hollow tile walls, and had gable roofs supported by steel roof trusses. Damage to these buildings was caused by extreme air pressure from the explosion. Most of the gable roofs had a 1:4 pitch, and were not designed to withstand the direct perpendicular force of the explosion. As a result, roof trusses collapsed and often pulled down tile or brick walls.[45] Damage to buildings located more than 3000 feet from the blast area was less severe. Many buildings had roof trusses which were partially destroyed, but their walls remained intact. Other buildings suffered only moderate damage such as broken windows or slightly crushed roofs, but wood frame or temporary structures were generally devastated.[46]

The explosion at the Lake Denmark Powder Depot also caused considerable damage to civilian property. Many towns in the area reported damage, the most serious occurring in Mt. Hope (1 mile away), Hibernia (3-1/4 miles away), and Rockaway (3-1/2 miles away). An area of ten square miles was evacuated.[47]

Nineteen persons were killed including 16 military personnel and three civilians.[48]

Background to the 1926 Explosion

After World War I, the Navy was burdened with excessive amounts of unused ammunition and faced the difficult problem of storing these vast reserves of high explosives, smokeless powder, and inert materials. A great number of magazines were constructed at Lake Denmark during 1917-1918 to increase the capacity of East Coast storage depots. However, this effort was inadequate as all the East Coast storage facilities were quickly filled to capacity.[49]

The 1926 Explosion at Lake Denmark demonstrated the hazards of storing concentrated amounts of explosive materials. At the time of the explosion, both Storehouses No. 8 and No. 9 were dangerously overloaded and in violation of the laws of New Jersey relating to the manufacture, keeping, storage, transportation, and sale of explosives. These conditions were a contributing factor to the extensive damage caused by the 1926 Explosion.[50]

Aftermath of the 1926 Explosion

Salvage and clean-up operations could not begin at Lake Denmark or Picatinny Arsenal until all fires were completely extinguished. Two weeks were required to extinguish all fires before it was safe to begin the task of cleaning up debris, salvaging materials and filing damage reports.

In the area of the original detonation, great quantities of twisted steel girders, steel shrapnel, and brick fragments were widely strewn. Three distinct craters, on the sites of the three storehouses, marked the location of the original explosions. Unexploded shells and shell fragments, some as far as 3/4 mile from the site of Shell Storehouse No. 22 posed great problems for cleanup crews.[51]

300,000 tons of loaded and fuzed projectiles damaged by the explosion were transferred by rail to a Navy installation at Iona Island in the Hudson River and then dumped at sea. Some damaged fuzes and primers were burned on site. Salvaged materials included 7,809 tons of metal, which was sold for $191,910.[52] Other explosive materials were bulldozed into craters and covered over (as a result, two sites in the Navy Hill area remain quarantined today).

The Court of Inquiry, appointed by the Navy and headed by Rear Admiral Coontz, recognized the problem of inadequate ammunition storage facilities on the East Coast. The court's most urgent finding was for the segregation of high explosive storage facilities. In effect, the court's recommendation's led to a general revision of ammunition storage practices and three recommendations were made to the Secretary of the Navy:

1) The amount of high explosive material stored in any given facility should be limited to 143,000 pounds per magazine.

2) High explosive magazines should be constructed with a minimum allowable distance of 500 feet between buildings.
3) New design standards should be developed for the construction of storage buildings.

The Court of Inquiry also recommended that combustible materials, materials with low resistance to explosion, and materials with a tendency to fragment into hazardous missiles be eliminated from the construction of ammunition storage buildings.[53]

To relieve the problem of explosive storage congestion, the Court recommended that two ammunition depots -- one serving the East Coast, the other serving the West Coast--be specifically designed to store high explosives. Both ammunition depots were to be at least 100 square miles in size and be located in isolated areas.[54]

In response to the court's suggestions, 77 specially designed high explosive storage buildings were planned for the Navy's Mine Depot at Yorktown, Virginia. This installation, located on a large tract of property, was to serve as the Navy's East Coast high explosive installation. A large ammunition depot for the West Coast was located on a 140 square mile tract of land near Hawthorne, Nevada, and included 1,100 arch-type high explosives magazines.[55] The court was confident that completion of these new facilities would greatly relieve the congestion on the East Coast.

The Court of Inquiry further recommended that after salvage and repairs were completed at Lake Denmark, funds should be appropriated to construct six new storage magazines to be used only for storing inert material, propellant powder, and projectiles. Storage of live ammunition at Lake Denmark would no longer be permitted.[56]

Further ramifications of the Lake Denmark explosion provoked Congress to investigate all government-owned ammunition storage and explosive manufacturing facilities that posed a threat to civilian populations and private industry. The first Deficiency Act, signed by the President on December 22, 1927, requested the Secretary of War and the Secretary of the Navy to appoint a joint board of investigators to survey Army and Navy ammunition installations and report their recommendations for upgrading existing facilities and building new facilities.[57]

Reconstruction Phase 1926-1937

Following the explosion of July 10, 1926, the Chief of Ordnance appointed a board of Army officers to investigate the incident and to make recommendations on the future of Picatinny Arsenal. The commission, headed by Col. Tschappat, advised that Picatinny Arsenal be reconstructed and expanded to consolidate the Army's holdings in northern New Jersey.[58]

In reviewing the damage caused by the 1926 Explosion, three major factors were found which affected the extent of damage inflicted upon a building:

1) The distance from the explosion.

2) The structural strength of a building.

3) The extent to which a building was screened or protected from the direct impact of the blast.[59]

Rather specific conclusions could be drawn from analysis of the damage. For instance, reinforced concrete was discovered to be the most satisfactory building material because it best resisted shock waves. Buildings incorporating reinforced concrete barricades, partition walls and structural frames were not seriously damaged. Brick construction, while not as durable as concrete, was often able to withstand the shock of the blasts. Hollow tile walls generally did not have the strength to withstand the damaging effects of an explosion. However, tile was an effective material for non-structural infill walls because it did not form dangerously destructive shrapnel material. The weakest structural aspect of building construction was the standard gable roof truss. Additional bracing substantially strengthened the traditional gable, but flat roofs proved far more resistant to the damaging effects of a blast.[60]

Prior to 1926, the expansion of Picatinny Arsenal had been gradual in order to meet the changing demands and functions of the Army. The 1926 Explosion provided an opportunity to redesign the installation to meet the Army's specific and particular requirements. The Tschappat Board recognized these possibilities and reported:

> "During its inspection of damage to the Arsenal, the board considered the rearrangement of certain facilities with a view to greater safety and economy of operation. The board believes that facilities not involving explosives or unusual hazards should be separated from facilities involving such hazards by as great distances as practicable, when such separation can be effected without undue increased cost of operation of the plant as a whole.[61]

In December 1927, Congress approved plans for rehabilitating Picatinny Arsenal and appropriated $2.3 million in line with the Tschappat Board's recommendations for this purpose. Lt. Col. J.K. Crain, Ordnance Department, was appointed to direct its reconstruction. Essentially, the "new" Arsenal was divided into three distinct functional zones:

1) An area for the production of powder and explosives.
2) An area for testing powders and explosives.
3) An area for non-explosives manufacturing, including all research and administrative facilities.[62]

The prime reconstruction effort focused on the powder and explosives manufacturing area. The Nitrocellulose Smokeless Powder Plant (the 500 area) was built on its original site, with greater distances between buildings. A Complete Rounds/Melt-Loading Plant (800 area) was established along the west shore of Lake Picatinny. This was constructed as a major loading-line, designed to incorporate various loading procedures into one distinct production component. Four major loading and assembly buildings were constructed, connected by covered walkways to facilitate the production process. The Complete Rounds/Melt Loading Plant represented a major development in production conception and greatly enhanced Picatinny Arsenal's production capability.

A new Bag-Loading Plant (400 area) was established along the south shore of Lake Picatinny. Three major buildings which replaced the outmoded facilities were constructed specifically for this production process.

A new testing area (600 area), established on the plateau west of Picatinny Peak, consisted of structures specifically designed as testing facilities and marked advances in technological and scientific developments.

A small High Explosives Plant (1000 area) for the production of tetryl was constructed in an isolated area on the eastern ridge of Picatinny Peak. The new plant followed construction guidelines established by New Jersey State law and replaced the old Tetryl Plant.

The explosives storage area (900 area) remained essentially unchanged. However, several recommendations concerning safety procedures were adopted and many new sand-filled wood bunkers were constructed. The amount of ammunition stored at Picatinny Arsenal was reduced and, to insure the safety of surrounding areas, Congress appropriated funds for the purchase of additional lands.[63]

A new administrative building (Building 151) and a new chemistry laboratory complex (Building 162) were the major construction projects executed in the non-explosives manufacturing area. These two projects formed the nucleus of a new administrative district. The emphasis placed on administrative functions, and especially on research facilities, reflected a shift in the focus of the arsenal.

The reconstruction and expansion of Picatinny Arsenal established the installation as the Army's major ammunition facility. It also became the Army's development, research and manufacturing center for all types of ammunition, except for small arms and machine guns.[64]

The rehabilitation of Picatinny Arsenal was essentially completed by 1931 as the new production plants and research facilities were all operable. During the 1930s, additional maintenance and repair work was completed as part of the Works Projects Administration (WPA). Nine hundred WPA workers were employed in 1937 to make renovations and improvements.[65] By 1940, there were 567 buildings at Picatinny Arsenal. There were 342,000 square feet of storage space; the value of items stored was $37.5 million and the facility itself was valued at close to $10 million.[66] Picatinny Arsenal, having suffered tremendously from the explosion of July 10, 1926, had been completely revived.

World War II Production Phase (1938-1945)

The mission of Picatinny Arsenal, just prior to America's involvement in World War II, was to provide the Army with a munitions manufacturing center which included experimental and production plants for various propellants and high explosives. In 1940, the installation was producing the following materials at either experimental or peace-time production levels:

1) Smokeless Powder
2) High Explosives
3) Fuzes and Primers
4) Assembled Rounds of Artillery Ammunition
5) Bombs and Grenades
6) Pyrotechnics (Airplane Flares/Military Signals)

Picatinny Arsenal was an important explosives and ammunition research center. Though work was interrupted briefly by the 1926 Explosion, the Arsenal's research/development facilities served both the Army and private industry during the period between the wars. From 1918-1940, Picatinny Arsenal was responsible for the standardization of new designs for base- and point-detonating artillery fuzes, and for the development of nose and tail bomb fuzes. Picatinny Arsenal was also instrumental in redesigning and improving artillery primers, trench mortars, and rounds of chemical and tracer ammunition. New high explosive compounds, propellant compositions, fuze powders, primer mixtures and pyrotechnic compositions were developed by the Research and Chemical Branch. An important aspect of Picatinny Arsenal's mission was the development of up-to-date designs for munitions, and in the event of a national emergency, to provide private industry with production plans and training.[67]

On December 8, 1941, the United States was at war and private industry faced a major challenge to meet the demands of mass production. Of necessity, Picatinny Arsenal assumed an important role in:

1) Ammunition Manufacture/Production
2) Ammunition and Explosives Research
3) Civilian and Military Personnel Training

Production

At the outbreak of the Second World War, Picatinny Arsenal was responsible for producing most of the ammunition for American troops as well as much of the ammunition for our European Allies. It was the only major plant in the United States capable of full-scale production for any ammunition larger than small arms, and it was responsible for loading and assembling large caliber ammunition, artillery projectiles and bombs. Picatinny Arsenal remained the nation's only major munitions producer until the fall of 1942 when private industry was capable of accepting the burden.[68]

To meet these responsibilities, Picatinny Arsenal experienced another era of rapid expansion. Pilot plant and experimental projects were converted to production operations. Production lines were operated at full-scale and then expanded in order to cope with increasing needs. The facility operated 24 hours a day, 7 days a week; the work force grew from 1,800 to 18,000 workers.

To meet their needs, the Army established temporary worker's housing outside Dover. A portion of the employees lived in this housing, while many commuted from areas as far away as Newark and New York City.

During 1942, the production at Picatinny Arsenal expanded far beyond the Army's expectations:

PRODUCTION FIGURES PICATINNY ARSENAL[69]

Year	Production/Rate
1938	2,000 boosters/8 hr day
1942	72,000 boosters/24 hr day
1938	600 artillery fuzes/8 hr day
1942	173,000 artillery fuzes/24 hr day
1938	10,000 primers/8 hr day
1942	90,000 primers/24 hr day
1942	40,000 37mm complete rounds/24 hr day
	30,000 60mm complete rounds/24 hr day
	12,000 75mm complete rounds/24 hr day
	7,500 81mm complete rounds/24 hr day

Research and Development

The Technical Division was established in March 1925 and was responsible for all research and development work during World War II. Many important advances were realized during the war which developed new products or simplified production. Perhaps the most significant of these was development of an improved method for manufacturing Tetryl, a highly explosive material used as a booster charge in bombs and artillery shells. The new procedure, which discontinued the dimethylaniline process in favor of the dinitromonomethylaniline process, proved less hazardous and less expensive.[70]

Improvement in the production and composition of nitrocellulose powder was accomplished by the Propellants Sub-Section of the Technical Division. The first development was the discovery that wood-pulp could be substituted for cellulose-based powders. This was extremely important because of the scarcity of cotton.[71] The Propellants Sub-Section was also responsible for studies of powder ignition and for standardizing testing procedures.[72]

There also existed an important demand for flashless, non-hydroscopic cannon powders. The research staffs of Picatinny Arsenal and the DuPont Company were responsible for developing powder compositions to meet these specifications. DuPont developed the M_1 powder; Picatinny developed the M_3. Testing of both compositions at the arsenal was done for specific weapons (three-inch and 90 mm) with satisfactory results.[73]

The Mechanical Branch of the Technical Division was responsible for the design and development of ammunition. At the outbreak of World War II, the branch was responsible for the development of all artillery fuzes, boosters and grenades. During the war, a variety of special components were designed to meet the requirements of different warfare tactics. Special bomb fuzes were designed-- one for above ground detonation and another for long delay

(1 to 144 hour) detonation. Pyrotechnic devices, flares and signals were designed or improved. All these devices were developed and tested at Picatinny Arsenal before undergoing further testing or combat action.[74]

The Chemical Engineering Section of the Technical Division was responsible for developing and evaluating new explosives and improving the performance of standard military explosives. Its most significant accomplishment was the invention of Haleite. Named for Dr. G. C. Hale, Chief of the Chemical Branch, this explosive was developed in co-operation with DuPont. A small production plant was established in the old Tetryl area.[75]

Training Program

The third significant function of Picatinny Arsenal was the establishment of training programs to impart knowledge of explosives and powder production to military and civilian personnel. The Ordnance School trained 300 reserve officers and 4,000 key ordnance personnel for special ordnance assignments. The men were later stationed among the 12 ordnance districts, to aid in establishing and maintaining ordnance facilities. To accelerate the transfer of ammunition production from the Army to the private sector, 530 engineers, chemists and executives from various industries studied ammunition and explosives production at Picatinny Arsenal.[76]

Picatinny Arsenal also developed a training program for 5,300 employees, the benefits of which were reflected in its excellent safety record. From

1940-1943, the facility's accident rate declined from 25.7 to 4.04 accidents per million man hours.[77]

The Arsenal's record proved that adequate safeguards and proper training could minimize hazards without jeopardizing the production output of an explosives manufacturing plant and demonstrated that the concept of "safety" in the explosives industry was possible.

The Role of the Lake Denmark Naval Powder Depot

The significance of the Navy's Lake Denmark Powder Depot in World War II is minor compared to Picatinny Arsenal. Though virtually destroyed by the 1926 explosion, Lake Denmark had since been used chiefly as a storage area for propellants and loaded projectiles. During World War II, the Navy's installation continued to operate in this capacity while it expanded in size. The Marine Corps barracks and a storage area (3300 area), comprising a total of 24 structures, were completed in 1939. A number of ordnance facilities were built during the war, most notably a heavy ordnance storehouse (Building 3050) completed in March 1942. In 1943-1944, a new barracks area was constructed to provide housing for enlisted men preparing to go overseas. Although this study could not discover any official documentation, it was alleged that this area (3400 area) was built to serve as a prisoner of war camp during the last years of the war. The area was constructed as a self-sufficient entity surrounded by a high security fence and served by its own powerhouse. Evidence of guard towers still remain but it is not believed that any war prisoners were ever held here.[78]

Significance of the Arsenal In World War II

World War II represents the zenith of Picatinny Arsenal's production development. The achievements of Picatinny Arsenal were recognized on September 20, 1942 when the Army-Navy "E" Award was bestowed upon Picatinny Arsenal for excellence in the production of ordnance. A second "E" Award was bestowed in August 1943, in further recognition of the Arsenal's important role in the nation's military effort.[79] The technological advances of World War II created great opportunities for research and Picatinny Arsenal continued to develop new and more effective munitions during the post-World War II period.

Post-World War II

Following World War II, the Cold War forced a continued posture of military readiness. Picatinny Arsenal was ideally suited to contribute to the national defense because it combined laboratory, production and testing facilities at one installation. Research and Development study areas included pyrotechnics, plastics, packaging, explosives, rockets and missile warheads. Picatinny Arsenal had long been involved in the field of pyrotechnics and continued in this capacity. It was responsible for all military pyrotechnic devices for the Army and the Air Force. Post-war activities in this field included the research, design, and development of photoflash cartridges for tracking missiles, photoflash bombs, flares, signals, smokes, tracers, spotting charges, and simulated charges.[80]

The Arsenal also continued its research in the packaging of ammunition, including the study of plastics and adhesives. The installation was equipped to measure the mechanical properties of plastics and adhesives and to mold experimental quantities of development items. Testing facilities included equipment that could simulate different climatic conditions and handling hazards.[81] A Naval Air Rocket Test Station (NARTS) was established at the former Lake Denmark Powder Depot in the early 1950s to research and test liquid and solid rocket fuels.

Activity at Picatinny Arsenal increased once again with the outbreak of the Korean conflict in 1950. North Korean use of the Russian-made T-34 Medium Tank posed a serious threat to American forces until a new 3.5 inch bazooka capable of penetrating the tank's thick armor was developed. The rocket for this weapon was manufactured at Picatinny Arsenal on a pilot plant basis and was soon put into full-scale production.[82]

Research and Development work also continued throughout the Korean conflict. In 1952, researchers at Picatinny developed an atomic shell capable of being fired from an 250mm gun.[83]

Picatinny Arsenal's research in plastics gained importance as this type of explosive came to be more widely used in ammunition during the late 1950s and early 1960s. In December 1959, the Plastics Technical Evaluation Center (PLASTEC) for the Department of Defense was assigned to Picatinny Arsenal. PLASTEC was responsible for compiling and evaluating information on plastics in the fields of packaging, electronics, structural and mechanical uses.[84]

The post continued to be a major center for explosives research throughout the 1950s and 1960s. Research included high-speed photographic studies of the detonation of explosives and studies of the effects of nuclear radiation on explosives. These studies applied to nuclear and special weapons as well as to conventional munitions.[85] During the 1960s, there began development work on warhead sections for the Nike system -- a family of ground-to-air, anti-missile missiles.[86] Picatinny Arsenal was also responsible for the development of warheads for other Army missiles such as the Hawk, Corporal, Honest John, Littlejohn, Lacrosse, Redstone, Pershing, Sergeant, SAM-D, Lance and Safeguard.[87]

During the Vietnam conflict, Picatinny Arsenal was responsible for the production of bomb fuzes, mortar shells, tank mines and other ammunition, until private industry could go into full-scale production. Picatinny was also responsible for the development of many sophisticated weapons systems.[88]

Historical Overview: Footnotes

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TECHNICAL BACKGROUND AND TERMINOLOGY

To comprehend the technical activities of Picatinny Arsenal, some basic understsnding of explosives, the components of an explosive train, and the various types of projectiles is necessary. It is also necessary to understand the role of safety in the manufacture and handling of explosives. The following section is designed to provide a brief introduction to the subject. The bibliography at the end of this report also contains numerous references devoted to explosives, their history, production and use.

Explosives

An explosive is defined as a substance, which because of a blow, friction, or the application of heat, rapidly decomposes to a more stable form, usually a gas. This decomposition and increase in pressure is accompanied by the production of considerable amounts of heat. Explosives used by the military are classified as "low" or "high" explosives.

Low explosives are those substances whose rate of decomposition is slow enough to make them safe as a propelling charge in a gun. These are referred to as deflagration or burning explosives. The "action" associated with low explosives can be described as follows:

> "The explosion progresses from the initial point by the heating of successive layers of the explosive to the explosion temperature. These explosives therefore burn on the outside or exposed surface only. In these explosives the rapidity of reaction is not great

> under ordinary conditions, but increases greatly if the explosion takes place under high pressure....Different low explosives differ considerably in their rapidity of reaction or, as usually expressed, their rate of burning."[1]

Black powder is an explosive that can serve as both a low and high explosive, depending on how it is used and contained. Until the late nineteenth century it was the sole explosive in military use and it found service as both a propelling charge and the projectile charge. With the development of new high explosives in the 1880's it was used primarily as a propellant. Today, black powder is primarily used as a delay element in a fuze and the exploding charge in a grenade. Black powder is hydroscopic (i.e. it reacts with or absorbs water), unstable, has a burn rate difficult to control, is dangerous to handle, leaves a residue in a gun barrel that corrodes metal and produces excess flash and smoke.

Nitrocellulose is another common low explosive. It is a product of the nitration of cotton, is generally referred to as smokeless powder, though it is neither smokeless nor a powder. Developed in 1838 by Pelouze, the early use of gun cotton, as it was first called, was marked by disaster. In its raw form, gun cotton is entirely too sensitive and unfit for general use. In 1886, Paul Vieille used ether and alcohol to colloid the gun cotton, and his Poudre "B" was quickly adopted by the French Military. Alfred Nobel mixed nitrocellulose and nitroglycerine to form the first double-based powder, Ballistite and, in 1889, the British took as their standard military propellant powder an adaption of the Nobel powder which they called "cordite," composed of 58% nitroglycerine, 37% nitrocellulose, 5% petroleum jelly.

Shortly thereafter the US Navy built a smokeless powder plant in Newport, RI where Lt. Bernardou developed a straight colloided nitrocellulose containing 12.45% nitrogen. The Army closely followed the Navy experiments and in 1907 built their own nitrocellulose plant at Picatinny Arsenal.

World War I exposed the weaknesses of nitrocellulose as a propellant. In too dry a climate, the solvents vaporized and thus increased its rate of burn. In a wet climate, it absorbed moisture and the rate of burn decreased. World War I was the first conflict in which night firing of large guns was a common occurance. Nitrocellulose was not desirable for such purposes because it produced a brilliant flash which revealed the location of gun emplacements. As a response to this deficiency, in 1917-1918 Picatinny Arsenal developed P.A. Compound #2, (oxnilid and glue), which was shredded and mixed with the powder grains or bagged on top of the propellant charge. It served to cool the gases below the flash point when they were ejected into the atmosphere. P.A. Compound #2 worked, but there was still a demand for a powder that was both non-hydroscopic and flashless without any additives. In 1929, DuPont developed FNH Powder M1 that was flashless in some guns and non-hydroscopic in all. Picatinny researchers developed P.A. Flashless Non-Hydroscopic Powder, M3 in 1936 using pyrocotton with a nitrogen content of 12.6%, diphenylamine (DPA), a stablizer which inhibits deterioration of powder, dinitrotolulene solid which reduces hydroscopicity of the powder, and dibutylphthalate (DBT), an inert cooling agent added to form FNH. The ratio of the chemicals depended on the gun for which the powder was intended.

When an explosive decomposes at such a rate as to be considered instantaneous, it is considered a "high explosive." The "action" associated with high explosives can be described as follows:

> "...the explosion travels from the initial point in a wave of vibration known as the explosive wave. The successive layers of [of the explosive] are not raised to the temperature of explosion by the heat derived from the preceeding ones, but the energy required to break up the successive layers is furnished first by the initial impulse produced by a primer or other means, and then by the explosive wave. The explosive wave consists of molecules of the products of combustion of the part of the explosive last exploded. The impact of these rapidly moving molecules on the adjacent parts of the explosive causes it to explode and furnish in turn new rapidly moving molecules of the explosive wave. The speed of the explosive wave, or rate of detonation, varies considerably in different high explosives."[2]

This highly disruptive effect on the surrounding medium is called a detonation. The characteristics of high explosives make them unsuitable as propellants but ideal as bursting charges.

High explosives are categorized according to their energy, rate of detonation, sensitivity to friction or a blow, and brisance. Brisance "refers to that quality or property of a high explosive evidenced by its capacity upon detonation, to shatter any medium confining it."[3] Primary explosives (single compound) are differentiated from derived explosives (usually TNT mixed with other primary explosives). High explosives used or produced at Picatinny Arsenal included:

1) TNT - Trinitrotoluene. Known as early as 1863, it was first used as an explosive in 1904. TNT is safe under normal handling conditions. It will not form unstable compounds with metals, does not absorb water, and is a powerful, brisant explosive. However, TNT does pose a health threat unrelated to its explosive capability. Vapors released during the production of TNT are poisonous as is TNT dust.

2) Tetryl - Trinitropheylmethylnitramine. A derivative of Benzene, Tetryl is almost insoluble in water and is more sensitive to shock or friction than TNA (see below). It is readily exploded by the penetration of a rifle bullet. Though not a good bursting charge, it is an excellent booster, or initiator of the bursting charge. Tetryl is poisonous if ingested.

3) Trytol - 65% Tetryl and 35% TNT - Trytol has about the same sensitivity and brisance as Tetryl but, unlike Tetryl, it can be cast. Trytol is used as a bursting charge.

4) TNA - Tetranitroaniline. Derived form benzene, TNA was first patented in 1912. It does not absorb moisture, will not react with metals, and creates poisons as it is produced. TNA is sensitive to shock or friction and will explode violently when hit with rifle fire. TNA is expensive to manufacture.

5) Amatol - Ammonium Nitrate and TNT either 50/50 or 80/20. The compound is hydroscopic, relatively insensitive to blows or friction, and will detonate from a severe impact or blow. Amatol will not form compounds with metals other than copper and tin. More insensitive than TNT it has the same rate of detonation and the same explosive strength. It is formed by melting TNT in a steam jacketed mixer, adding ammonium nitrate, and then stirring until each

grain of ammonium nitrate is coated with TNT. 50/50 Amatol is very fluid and can be poured or cast in shells. 80/20 Amatol is plastic, like moist brown sugar, and is filled by tamping or screwing.

6) Cyclonite (cyclotrimethylenetrinitramine) - the RDX's (Research Department Explosives). In its pure form cyclonite is highly sensitive and brisant, and cannot be cast. RDX Compound A is 91% cyclonite and 9% wax. It is a good explosive for armor piercing shells. RDX Compound B is 60% cyclonite, 39% TNT and 1% wax. It is especially good for fragmentation bombs. RDX Compound C is 88% cyclonite and 12% plasticizer. More brisant and just as insensitive as TNT, Compound C can be formed on the spot, shaped or tamped into place, making it an ideal demolition explosive.

7) Haleite (ethylene dinitramine) - EDNA. Named for Dr. Hale, former head research scientist at Picatinny Arsenal, for many years Haleite had the highest brisance of explosives of comparable sensitivity and a higher rate of detonation than TNT. EDNA cannot be cast.

8) Mercury Fulminate. Derived from the interaction of alcohol on mercury nitrate in nitric acid solution, mercury fulminate is only produced in small amounts. Mercury fulminate detonates completely and with violence from a spark or hot wire. It is a most suitable detonator material since it will not absorb moisture. When dry it will not react with metals; when wet, it will react with brass.

9) Lead Azide - (PbN_6). A white crystalline power, lead azide has largely replaced mercury fulminate as a detonator material. Nonhydroscopic, it has good stability once pressed into a detonator cup. Before pressing, it is so

dangerous that it must be stored in water and handled only in very small amounts.

10) <u>Explosive D - Ammonium Picrate</u>. Explosive D was patented by Alfred Nobel in 1888. It is very insensitive to shock and friction and well suited as a bursting charge in armor piercing projectiles. Explosive D is manufactured by the neutralization of picric acid with ammonia. There are no serious dangers in its manufacture and it can be loaded with hydraulic pressure or hand stemming.

11) <u>Picric Acid - Trinitrophenol</u>. Picric Acid was developed in France as an explosive in 1886. It is derived from benzene, an inflamable liquid byproduct of the manufacture of coke. It readily forms sensitive explosive salts when in contact with metals. A weak poison, picric acid is also known as a dye.

12) <u>Nitrostarch Explosives</u>. Adopted during World War I to compensate for the shortage of TNT, Nitrostarch is formed by the treatment of starch with a mixture of nitric and sulphuric acids. Cassava and tapioca starches provide the best service. More sensitive to impact than TNT, it was fairly cheap to produce. Trojan grenade explosive and trojan trench mortar shell explosive were composed of 40% nitrostarch and varying amounts of ammonium nitrate and sodium nitrate. Grenite contained 95% nitrostarch.

IMPORTANT HIGH EXPLOSIVES ARRANGED BY SENSITIVITY AND BRISANCE

<u>Decreasing sensitivity</u>		<u>Increasing Brisance</u>	
Mercury fulminate	5	Lead azide	18
Lead Azide	10	Mercury fulminate	22
PETN	17	Explosive D	
37			
EC blank fire	19	Amatol 50/50	39

Decreasing Sensitivity		Increasing Brisance	
Tetryl	26	TNT	43
Tetrytol	28	EC blank fire	45
Cyclonite	32	Tritonal	46
Pentolite	34	Ednatol	48
Torpex	38	Haleite	51
Haleite	48	RDX-B	52
RDX-B	75	Trytol	52
Amatol 50/50	95	Tetryl	53
Ednatol	95	Pentolite	53
TNT	95-100	Torpex	58
Explosive D	100+	Cyclonite	59
Tritonal	100+	PETN	62

The Explosive Train

"The explosive train" is the term used to describe the process of detonation in military ammunition. The sequence of action and number of actions may vary but in both the propellant explosive train and the projectile or bomb explosive train the basic actions remain the same.

The initiator of all action is the primer, usually black powder, which is ignited by a spark, friction, or electricity. The primer in turn fires the detonator, which consists of small amounts of extremely powerful explosives (usually either lead azide or mercury fulminate). The detonator fires the booster, a larger amount of less volatile explosive. The booster, usually tetryl, is powerful enough to detonate the bursting charge, but in itself does not make a good burster. The bursting charge can be one of any of a number of explosives, depending on the purpose of the munition. This purpose may be armor-piercing, concrete-piercing, anti-tank, anti-personnel, pyrotechnic or chemical.

There are four basic stages in the explosive train of large scale military ammunitions. In general, the explosive train starts with the ignition of a relatively small amount of highly sensitive explosive in the primer. The blast of the primer then ignites the detonator which, in turn, ignites the booster which then sets off the bursting charge. Because of this "chain reaction," it is possible to ignite a large amount of relatively stable high explosive (the bursting charge) in a relatively short period of time. If there is a need to delay or time the action of the fuze, relay or delay pellets of black powder can be added to control the timing of the detonation. With this system, it is also possible to keep the fuzes and bursting charges separate from one another until the bomb is actually to be used, thus allowing the bursting charges to be handled without fear of premature explosion.

GLOSSARY OF ORDNANCE TERMINOLOGY

(Note: This glossary emphasizes historically relevant terminology. It is not intended as a comprehensive listing of modern ordnance terminology.)

Aircraft Ammunition: Anything dropped out of a plane, including bombs and certain pyrotechnics. Bombs, pyrotechnic ammunition, and rocket ammunition are classified in the same fashion as artillery ammunition.

Ammunition: Any material used in attack or defense in warfare intended to inflict damage upon the enemy; artillery, aircraft, rocket, small arms, etc.

Artillery Ammunition: Classified three different ways. 1. According to service use: Service Ammunition (used to inflict damage upon the enemy); Practice Ammunition (used to train troops); and Blank Ammunition. 2. According to tactical use: High Explosive, Armor Piercing, Chemical, Smoke. 3. According to the method of containing the propellant: Fixed, Semi-Fixed, or Separate Loaded.

Artillery Primer: A device for igniting the propellant powder that imparts motion to the projectile, located in the end of the cartridge case with the powder.

Brisance: That quality or property of a high explosive evidenced by its capacity, upon detonation, to shatter any medium confining it.

Caliber: Diameter of the bore of a gun, measured either metrically or in inches. It also describes the size of ammunition.

Cannon: A weapon too heavy to be carried by hand including guns, howitzers and mortars, except for trench mortars.

Cartridge: A complete round of small arms ammunition, or the casing that contains propellant powder for fixed or semi-fixed ammunition.

Complete round: All components required to fire a gun once; the ultimate objective in artillery ammunition design and manufacture; not necessarily physically attached as a unit. Artillery ammunition is classified according to service use (service ammunition, target or practice, drill, blank-saluting); tactical use (high explosive, armor-piercing, chemical, smoke, illuminating, cannister, or special).

Deflagration: Slower reactions of low explosives, or burning.

Detonation: Comparatively fast rate of reaction of an high explosive.

Detonator: A stage in the explosive train, used to set off an explosion.

Explosive: Substance that rapidly changes from its initial state, usually but not necessarily a solid, to a gaseous state by application of heat, friction, a blow, etc.

Explosive Train: The steps taken in military ordnance to control the explosion of a shell, bomb, etc. The steps include the primer, detonator, booster, and bursting charge.

Fixed: One type of a complete round of ammunition, where the propellant powder is contained in a cartridge case permanently attached to the projectile.

Fuze: A mechanism or device for controlling the ignition or detonation of a projectile.

Fuze Primer: A small explosive component for initiating a detonation in an explosive train and transmitting it to the next component.

Grenades: Explosive or chemical-filled projectiles of a size and shape convenient for throwing by hand or projecting from a rifle or a launcher. Grenades are designated defensive, offensive, or chemical.

Guns: Long-range, high-velocity, high-pressure weapons fired at low elevations. They are the heaviest type of cannon.

High Explosives: Initiated usually by shock or blow, high explosives have a very high rate of reaction and disruptive effect.

Howitzer: Shorter, lighter-weight weapon fired at higher elevations than guns, resulting in shorter range, and at targets which cannot be reached by direct fire.

Land Mines: Containers, metal, plastic, or wood, filled with high explosives or chemical agents. They are designed for placing in or on the ground for detonation by enemy vehicles or personnel. They can also be denotated by remote control.

Loading: The filling of shells, bombs, etc. by means of casting, pressing, or pelleting.

Low Explosives: Initiated by flame or spark, lower rate of reaction and less disruptive effect than high explosives.

Mortars: Weapons even shorter, lighter and more mobile than howitzers. The muzzle velocity and chamber pressure are less and the angle of fire is greater, particularly for trench mortars which are of the smooth-bore variety. Some of the larger mortars are rifled. Mortars are used against troops in trenches or foxholes, machine gun nests, and obstructions and barriers, and they are adapted to plunging fire at high angles even up to 85 degrees. They are excellent for firing over local obstructions and hills, preparatory to infantry advance. They provide indirect fire, usually with a high trajectory.

Munition: Armament or ammunition.

Ordnance: Everything the Army fights with including tanks, artillery and ammunition, self-propelled mounts, carriages and recoil mechanisms, fire control apparatus and instruments, combat and transport vehicles, small arms and ammunition, rocket launchers and rockets, bombs, pyrotechnics, grenades, and mines.

Percussion Primer: Fired by a firing pin, the flash being transmitted to the powder charge.

Primer: Element of the explosive train. It ignites the powder charge.

Rifle: A weapon using rifling in its barrel to impart a stabilizing twist to a projectile.

Rocket: A container in which gases are generated at high pressure with a vent or nozzle through which gases escape in the form of a jet.

Rocket launchers: Guide rails or guide tubes fitted with an electric ignition device.

Semifixed: A form of the complete round of ammunition. The propellant powder is contained in bags in a cartridge case not permanently attached to a projectile, but removable in the field so that the charge may be adjusted.

Separate Loaded: The third form of the complete round of ammunition. Propellant powder is contained in bags which are loaded separately into the breech of the gun behind the projectile.

Small Arms: Weapons .60 inches or under in caliber used primarily by the infantry; rifles, semi-automatic rifles, automatic rifles, pistols, carbines, machine guns, submachine guns.

Small arms ammunition: Bullets; categorized as ball, armor-piercing, tracer, incendiary, or guard. Small arms ammunition also includes blanks, rifle-grenades, subcaliber ammunition and shotgun shells.

Small Arms complete round or cartridge: Contains a bullet to perform the mission at the target, a cartridge case to contain the primer and propellant powder, and a primer to ignite the propellant powder when the firing pin strikes it.

Tracers: A bright burning composition placed at the base of a projectile. The use of tracer shells, especially in night firing helps control the direction of fire.

Weapon: A device for inflicting damage upon the enemy by projecting missiles and ammunition.

Zone Fire Charge: A system of loading semifixed and separate load propellant powder into a series of bags so that, in the field, the number of bags being used to fire a projectile can be changed to adjust the range of fire of a weapon.

Technical Background and Terminology Footnotes:

1) Tschappet, William, Textbook of Ordnance and Gunnery (New York: John Wiley and Sons, 1917).

2) Ibid., p.4.

3) Hayes, Thomas J., Elements of Ordnance, New York: John Wiley and Sons, 1938.

200 AREA - SHELL COMPONENT LOADING DISTRICT

The Shell Component Loading Area lies within the security enclosure and runs north of Rielly Road from 6th to 10th Streets. A wooded ridge lies to the northwest and north of the area. The 600 Test Area is uphill to the northeast and the 300 Area lies to the south and southeast. Open space to the southwest separates the 200 Area from an administrative center of the installation. Bear Swamp Brook runs through the center of the 200 Area and a small swamp separates several buildings containing volatile chemicals and processes from the rest of the district. Other buildings are separated from one another by wooded areas, swamp, man-made hills and/or barricades.

There are more than 70 buildings within the 200 Area, including many of the oldest in the arsenal. The majority of structures are of hollow tile construction but during World War II temporary wooden and galvinized steel buildings were erected during a period of rapid expansion. Many of these were still standing as of 1983. Listed below are the building number, function, and date of construction for major structures standing within the 200 Area in the summer of 1983:

200 AREA BUILDINGS

Building	Function	Date
210	Time Fuze Load	1918
213	Fuze Load	1916
214, 216, 240, 257	Change Houses	1941
215	Press House	1919
221	Cast High Explosive Fill Plant	1941

200 AREA BUILDINGS (Continued)

Building	Function	Date
224	Control House	
225	Machining	
230	Primer and Detonator Load	1918
231	Control Bunker	
232	Detonator Assembly	1918
234	Annealing and Curing	
235	Mercury Fulminate	1918
238	Press Facilities	
241	Explosive "D" Load	1919
247	Hydrostatic Press Facilities	
252	Press Load	1918
252C	Ammonium Picrate Screening	1920
256	Booster and Fuze Load	1889
266	Pump and Change House	1903
267	Ordinance Facility	1941
268	Primer Explosive Sewing Room	1941
269	Primer Load	1941
271	Fuze Assembly	1905
271E,K	Heater Houses	1941
271F	Field Office	1943
271H	Lead Azide Preparation	1942
271I	Lead Azide Primer	1941
271J,L	Dry Houses	1941
276	Melt Load	1902
281	Office, Change House & Pelleting	1921
282	General Purpose Magazine	1942
295	Lead Azide Primer Mix	1942
296	Operating Building	1941

The 200 area contains some of the post's earliest storage magazines: Buildings 256 (1889), 276 (1902), and 271 (1905). Following World War I, the Army chose to establish new shell loading lines and most of the 200 Area structures were built as part of this initiative. Complete rounds of ammunition were assembled in the district until the construction of a separate melt load area (800 Area) in the 1930's.

While some shell filling continued through the late 1930's, during World War II most of the activities within the 200 Area concerned fuze production.

After the war, the emphasis shifted to the research and development of speciality fuzes and timing devices. Though production resumed during the Korean and Vietnam conflicts, today many of the buildings have been abandoned. Others, having been made "energy efficient," are periodically used for pilot production runs and experimentation.

Operations

While some shells were loaded in the area during World War II, the majority of buildings in the 200 Area were used for the production of fuze components (primers, detonators, delays, relays, boosters) and for the assembly of the complete fuze. Because of the highly sensitive nature of the primary explosives used (mercury fulminate and lead azide), their production and handling required great care.

The loading of shells with explosives began in 1902. Loading shells involves the pouring of a melted or pelleted high explosive into the body cavity of a shell, drilling a hole in the explosive to hold the booster charge, and then assembling the shell body, fuze, fins, propellant, etc. into the complete round. Although this is examined more fully in the chapter on the 800 Area, it is important to note that the first loading of shells at Picatinny Arsenal took place in the 200 Area.[1]

The high explosive initially used in the filling of shells was Maximite. Developed by Hudson Maxim, Maximite was a mixture of 90% picric acid

(Trinitrophenol) and 10% mono-nitro-naphthaline. Picric acid is an especially disagreeable compound which discolors the skin and destroys clothing. Difficulty in finding men willing to work with this chemical delayed the start of shell filling until August 1903.[2]

To produce Maximite, 85 to 90 pounds of steam pressure was used to melt the mono-nitro-napthaline in a kettle and the picric acid was slowly stirred in. The melted Maximite was then poured into the shells. The Maximite loading installation lasted about two years because of major problems with cavitation (or shrinkage) as the maximite cooled. When a cavitated shell was fired, these cavities would collapse, the charge would move in the shell, and premature detonation could occur.[3]

Because of these problems, Maximite was soon replaced by Explosive "D" as a bursting charge. It was formed from picric acid by mixing the acid in a hot water solution with strong ammonia.[4] Insensitive to shock and friction, it was ideally suited as a bursting charge in armor-piercing shells.[5] Instead of melting and pouring the explosive, the composition was loaded at a plant either by a hydraulic press or by hand stemming (or packing) premeasured amounts into a shell. The post's first Explosive "D" packing plant operated as needed until 1917 when production procedures were changed to overcome problems caused when Explosive 'D' came into contact with the metal sides of a shell. To accommodate these changes, a new facility (Building 241) was constructed in 1919. There, TNT was melted, poured into a shell, allowed to set for a few minutes and then poured out. A small amount of TNT would be left inside and this would separate the walls from the Explosive "D" that was added later. However, the TNT still tended to break away from the walls of the shells and this process was quickly discontinued.[6]

Explosive "D" loading underwent a number of changes after World War I. As a result of the Army's decision to make Picatinny Arsenal a complete ammunition arsenal (except for the fabrication of metal components), rapid expansion of the facilities (accompanied by changes in the chemistry of Explosive "D") resulted in a new system which could load 12-, 13-, or 16-inch shells at a rate of 100 per eight hour shift. New automated and semi-automated machinery replaced many of the hand ramming operations, and the density of the explosive was increased from 1.35 grams per cubic centimeter to between 1.45 and 1.50. A higher density increased the stability of the explosive when used in armor-piercing shells.[7]

Most of the Army's experimental work on shells, fuzes, fillers, etc. took place in the Picatinny Arsenal's laboratories, and this research continually affected activities within the 200 Area. The redeveloped system for loading shells involved moving the items onto a turntable for loading and pressing. Each operating turntable had four steps:

1) Load a shell onto a truck on the turntable. Rotate 1/4 turn.

2) Shell #1 moves to be filled with the charge while Shell #2 is put into place. Rotate 1/4 turn.

3) Shell #1 moves through barriers into place under the water pressure ram, Shell #2 is loaded, and Shell #3 placed on the turntable. Rotate 1/4 turn.

4) Shell #1 is off loaded, Shell #2 is pressed, Shell #3 is filled, and Shell #4 is placed on the turntable. Rotate 1/4 turn.

This process would then be continued indefinitely. Elaborate guides ensured that the shells were properly placed in the ram so there was no contact between the ram and the sides of the shell. It was noted that the smaller the grains were allowed to become, the more difficult it was to press them completely within the shells. Consequently, an effort was made to produce grains as large as possible.[8]

Everything changed after the 1926 Explosion. Although the 200 Area was not severely damaged, the reorganization and rebuilding of the arsenal after 1926 and the development of a separate melt load line in the 1930's (the 800 Area), changed the emphasis of activity in the 200 Area. During World War II, 200 Area activities focused on the production of fuzes.

Explosives Used In Fuzes

A fuze is a device placed in a projectile, bomb, mine, mortar or grenade that is designed to insure detonation of the bursting charge. Fuzes contain two to five basic components which, with the bursting charge, form the explosive train. They are often referred to as "initiators" because they are responsible for starting the chain reaction of an explosive train.

Mercury fulminate was discovered in 1799 but it was not utilized as an explosive until 1864 when Nobel began to use it as a detonator explosive. It was the primary explosive used as an initiator until World War II when it began to be replaced by lead azide. Mercury fulminate is produced by the action of alcohol on mercury nitrate in a nitric acid solution. Because of its sensitivity, it is produced in very small batches. Slightly more sensitive than lead azide, mercury fulminate loses stability in hot humid conditions and some sensitivity if pressed into pellets using excessive pressure.[9]

Lead azide was discovered in 1890, but was not substituted for mercury fulminate as an explosive until 1907. A white crystalline powder, lead azide (PbN6) is the most common initiator now in use. Only slightly less sensitive than mercury fulminate, it is easier to press into pellets or into detonator cups. Care must be taken in the production of lead azide to form crystals of the proper size because if the batch is allowed to grow too large, they will spontaneously detonate. Lead azide is usually stored in water-filled crocks within concrete vaults that are also filled with water. It is used and handled in small lots.[10]

Black powder (a mixture of charcoal, sulfur, and potassium nitrate) was produced part of the way up the ridge between the 200 and 600 Areas. Its production is described within the section on the 600 Area. Black powder was used in fuzes both as primer and as delays. When inserted in the explosive train of the fuze its relatively slow rate of burn would act as a delay. This proved especially useful in armor and concrete-piercing shells where the shell needed time (measured in fractions of a second) to penetrate its target.

Tetryl was produced in the 100 Area, southeast of the 200 Area. Tetryl is almost insoluble in water and is fairly sensitive to shock or friction. Though not brisant enough to act as a good bursting charge, it was brisant enough to make a good booster. Tetryl was also pressed into pellets and added to lead azide in the detonator cup of the fuze.

Fuzes are the "brains" of a projectile in that they control the detonation. Fuzes were designed to detonate on impact or by timer and could be placed either in the point or in the base of a shell.[11] While the metal components were manufactured elsewhere, the explosives were prepared and the fuzes assembled at Picatinny Arsenal.

Primer assembly took place in Buildings 203, 204, 218 (all demolished by 1983), 230, 268 and 269. In isolated buildings, small amounts of lead azide and mercury fulminate were pressed in foil, waxed, waterproofed, sealed, dried and stored. The assembly of detonators took place in Buildings 230 and 232. The detonator was generally the second step in the explosive train, and its fabrication became highly mechanized during World War II. The assembly of the primers, detonators, relays, delays, etc. into the complete fuze was accomplished in Buildings 210, 213, and 271.

Changes In Technology

Between World War I and World War II, Picatinny Arsenal worked to change manufacturing techniques and moved from hand operations to semi and fully automatic processes. Aside from the greater safety resulting from fewer people handling explosives, the increase in automatic processes helped achieve greater product uniformity. It also proved to be more economical.

World War II brought this effort to a head. As the major producer of large caliber ammunition, the Picatinny Arsenal was under pressure for increased production while at the same time its trained personnel were sent out to supervise the establishment of other ammunition facilities.[12] As quickly as possible, equipment of commercial design was adapted to work with explosives and the post was often forced to seek outside sources for machinery. Here too, problems caused by the war apparently interfered with arsenal needs. Because the machine fabrication industry could not perceive a major postwar market for highly specialized munition machinery, the arsenal's efforts to alleviate its munitions problems were hampered. However, a number of firms did respond to the challenge and assist the war effort in this important area.[13]

As evidenced in this description, the R. A. Jones Detonator Loading Machine was a complex piece of equipment:

> "Tetryl pellets are loaded in a feed tube by hand, and this tube is put in place; lead azide or mercury fulminate is volumetrically measured and fed manually; the detonator cups are hopperfed. With raw materials assured as above, the steps are: (1) A detonator cup slides down from the hopper to be released. (2) The cup is tripped to the correct position. (3) An arm slides the cup forward. (4) A chuck forces the cup into a sleeve on the turntable. (5) At the next station, the cup is gaged. A short cup, an inverted cup, no cup, or a cup with a malformed top will automatically stop the machine. The cup is removed by hand and another is inserted. (6) A tin-foil disk for the

> bottom of the cup is punched and seated in one process. (7) The cup is gaged for 'high cup.' If stopped automatically, the cup is removed, and a proper-sized cup replaced. (8) An operator measures a level scoop of explosive and pours it into the cup. The process inspector performs a ten per cent test of the scoop every hour. (9) The charge is consolidated under a spring-loaded press to a predetermined pressure. (10) One tetryl pellet is fed into the cup from the tube. (11) The charge is consolidated to a fixed height that will produce a definite over-all length after crimping. (12) The cup is closed with a disk of colored tin foil which is punched and deposited from a roll. (13) The cup is crimped at a 45-degree angle, excess powder removed, and then flat-crimped (14) The completed detonator is lifted from the sleeve by a finger and knocked out. (15) An operator removes the detonators from the chute and boxes them. (16) Another operator performs a one hundred per cent inspection test and trays the detonators."[14]

Development of a machine that could handle mercury fulminate, lead azide, tetryl, TNT, etc. and safely load them into detonators meant that five operators could load 8,000 detonators during an eight-hour shift in a space 6 X 6 X 7 feet. Manually, it took 17 to 20 operators eight hours to load 7,500 detonators in a space 20 X 50 feet.[15]

Other equipment used in fuze assembly included machinery for punching out a detonator cup and setting the disk in the bottom. Machines by the Aluminum Seal Co. and the Consolidated Packaging Machinery Co. produced about 30,000 cups per shift, equal to the production of 26 employees working by hand. A machine developed by Consolated Packaging Machinery Co. loaded black powder charges into primers at a rate of 1,500 per hour.[16]

A loader developed by the Waterbury Farrel Foundry and Machinery Co. helped speed up one of the most time consuming jobs associated with the primers;

inserting paper liners in the primer body. The Waterbury machine could load 20,000 per shift, freeing workers for other jobs and opening floor space. Similarly, the Pennsylvania Machinery Co. developed machinery to assemble the primer head and their rotary-type, hopper bed, dial machine produced 30,000 primer heads per shift. It eliminated 25 operators and reduced floor space requirements by 90%.[17]

Saving space was as important as speeding up production and reducing the number of employees. New buildings were constructed as fast as possible but equipment and people were often moved in and production started before a building was officially complete.[18]

The Arsenal's success in mechanization is highlighted by these statistics on fuzes and parts produced before and during World War II:[19]

	Boosters	Fuzes	Primers
1938	2,000	600	10,000
1940	4,000	1,500	10,000
1942	72,000	173,000	90,000

The scientists and engineers associated with fuze production were forced to change the design and purpose of their product as the character of the war changed. On-demand service became standard. For example, the Navy's call for 200 special bomb fuzes in 1944 resulted in 48-hour loading, assembly and delivery.

Similarly, the introduction of low level skip bombing in 1943 meant that there had to be a delay in a fuze to allow airplanes time to leave an area before detonation. In response to this need, a special fuze with a variable 8-11 second delay was devised.[20] In the area of pyrotechnics, explosives, fuzes, etc., Picatinny Arsenal was the center for military explosives needs but towards the end of World War II production slowed as contractors took over.

The Korean conflict again brought Picatinny Arsenal back to the fore as experimental weapons lines were overnight turned into full scale production facilities. A 3.5 inch bazooka being prepared for pilot production went into full production almost overnight at General MacArthur's request. Seven days later, these new rockets were in use in Korea.[21]

Fuze Assembly

Several fuze assembly lines were established in the 200 Area during World War II. The following information on the time fuze is based on data taken from the Ordnance Officers Course # Two offered at Picatinny Arsenal during the war.[22]

The major element of the time fuze was the ring. Rings carried black powder, the burning of which was timed to control the detonation of the explosive. Prior to loading the powder into the ring it was necessary to coat the powder groove with shellac and aniline dye composition. This was applied by hand with a cotton swab and allowed to dry for 72 hours. The rings were kept warm to keep condensation from forming on them. At each step identification numbers were stamped on the parts of the fuze to insure the isolation of blocks of rings causing trouble. The ring was placed in a loading fixture which supported the ring while it was loaded with powder. The column of powder loaded was approximately three times the height it would be after pressing. Every effort was made to keep the powder from bridging in the column and clogging. The first pressing was done with a hand operated press. It was then placed in a hydraulic press with pressure set at 68,000 lbs. per square inch for a 21 second fuze, and 75,000 lbs. for a 45 second fuze.

In the facing room, rings were brought to proper dimensional thickness using a lathe. They were then shellaced to protect them from moisture and chipping. Then they were moved to the dry house where they sat for three days in a temperature of 100-110 degrees F. Following storage in the dry house, the rings were drilled, reamed and cleaned. Pellets were added, the vent closing disc was placed, and the rings were again shellaced. After the final addition of pellets, felt was glued to the rings, and they were returned to the dry house for three more days of drying. At each step, rings were removed for quality assurance testing.

In the assembly room rings were waxed. The body of the fuze was prepared by applying aniline-shellac to surfaces that came into contact with the powder. Then the bottom closing screw was inserted, the body pellet was inserted, the felt was applied, and 95 grains of Grade A-4 black powder were placed in the base charge cavity. Lock pin holes were drilled and lock pins inserted. The concussion primers were inserted and the cap screwed on by hand. It was then set by machine to a tension of 60 to 65 inch-pounds. The completed fuze was buffed and lacquered to prevent moisture from affecting the black powder.

Finished fuzes were packed into metal lined boxes which were soldered shut, checked for air leaks, and painted and marked. 21-second fuzes were loaded 80 to a box, and 45-second fuzes were packed 25 to the box.

Testing and gauging was conducted at every step of the process as representative samples of fuzes and fuze parts were removed for testing during each shift. Hardness tests were conducted on the rings and burn tests determined if the rate of burn of powder rings and pellets fell within the set guidelines. Finished fuzes were fired statically to check for duds while jolt and jumble tests were designed to simulate the types of shock that fuzes would receive in handling.

The word "primer" is used to describe many different things, but all primers are used to initiate the explosive train, either in a bomb, a projectile, or propellant charge.[23] They can be fired by electricity, friction, or impact. Propellant primers initiate the action of the propellant. When the lanyard of a gun is pulled, the firing pin fires the primer which, in turn, fires a charge of black powder, which in turn fires the propelling charge.

Bomb primers are usually located in the tail fin area of the bomb and bombs are usually armed when they are released from a plane, as the result of spinning caused by the fins. Projectile primers can be placed in the nose or base of a projectile. Their action can be either timed or precipitated by impact, and impact primers can be either of the superquick or delay variety.

During World War II the material elements of the projectile primers were manufactured at Frankford Arsenal while Picatinny Arsenal loaded the primers and packed them.[24] Black powder loaded primers were filled by machinery capable of loading 10,000 primers during each eight-hour shift. After loading, the primers were waterproofed and dried before being crimped. Waterproofing operations included painting or dipping the primer in asphaltum. Excessive coating was removed with varsol-saturated cloths.

Safety conditions were of critical importance and machinery used in primer production was barricaded. Only small amounts of black powder or other explosive materials was used at any one time. The health of operatives working in the waterproofing rooms was a major concern as fumes from varsol are poisonous. Female operators proved to be more susceptible to skin poisoning, so male operatives using a protective grease on their hands usually did the work.

Accidents

Because activities in the 200 Area involved such volatile explosives as lead azide, mercury fulminate, black powder, tetryl, Explosive "D," and picric acid, there were accidents. Problems within the area usually were associated with: the handling of chemicals used in the explosives; the handling of chemicals used in cleaning and preparing elements of explosives; and dust and vapors. Steps were taken to ensure that workers did not come into prolonged contact with dangerous chemicals. However, if contact could not be avoided, breathing apparatus and protective clothing were available.

Whereas the health problems associated with chemicals could be studied and often mitigated by new techniques, detonations of materials being handled created different types of problems. Teams of investigators probed every explosive accident and determined the extent of damage to the worker, the building and machinery. They also tried to establish the cause of the accident and recommend ways of preventing similar accidents. Representative accidents described in the files of the arsenal included:[25]

1) On February 18, 1927 in Building 215 an operator received burns on her hands, chest and face when she dropped one or more friction primers, causing several hundred other primers to detonate. The review board noted that operators were not to pick up more than one primer at a time, and recommended that the number of primers in any one area be reduced when the operators were not working behind barricades.

2) On June 21, 1927 three women employees were injured when a $4.00 fuze detonated while being placed in a packing box. It was recommended

that a separate inspection of the arming devices of fuzes be made to determine that devices were properly set before being packed.

3) On October 24, 1928 one worker was killed, Building 218 received $200.00 worth of damage, and a detonator charging machine required $600.00 worth of repairs because of a blast of unknown origin. It was suggested that the operator accidently struck two items (detonators or non-spark proof tools) together while working on the detonator charging machine.

4) On March 11, 1929 one employee was injured and Building 232 received $800.00 worth of damage when one or more detonator casings were misaligned when placed in the machine to press the explosive. The pressing crushed the casings and caused the detonation of the explosive.

During the World War II, similar accidents occurred, most often in the handling of primers and detonators. At times, operators would ignore instructions and attempt to pick up or move too many items, dropping them or striking them together thus causing a detonation. Other accidents happened during the installation and experimentation of new machinery designed for producing fuze parts. Still, the accident and lost time rates were below that of the rest of industry during the war. This was probably the result of special design features and procedures used at the arsenal. For example, walkways through the 200 Area were marked by barriers and red lights, and persons moving lead azide from one building to another pushed wooden carts and called out warnings as they moved along. Another interesting safety feature was the use of slides (or chutes) to help people escape quickly from buildings in case of emergencies.

200 Area Footnotes:

1) Campbell, Levin H., Jr. The Industry-Ordnance Team. (New York: Whittlesey Publishers, 1946), pp. 40-41.

2) Harris, John P. "Loading Ammunition at Picatinny Arsenal." Army Ordnance, Vol. VII, No. 37 (July-August 1926): p. 41.

3) Ibid., pp. 41-42.

4) Hayes, Thomas J., Elements of Ordnance. (New York: John Wiley and Sons, 1938), p. 38.

5) Green, Constance McLaughlin; Harry C. Thomson; and Peter C. Roots. The Ordnance Department: Planning Munitions for War, United States Army in World War II, The Technical Services. (Washington, D.C.: Office of the Chief of Military History, U.S. Dept. of the Army, 1955), p. 367.

6) Harris, "Loading Ammunition at Picatinny Arsenal," p. 42.

7) Ibid., p. 43.

8) Ibid., p. 43-44.

9) "Lead Azide as a Detonating Explosive." Army Ordnance, Vol. VII, No. 32 (September-October 1926), p. 135.

10) Ibid., p. 136.

11) Brayton, H.M. "Fuzes: Modern Requirements and the Type of Organization Necessary for Fuze Development Work." Army Ordnance, Vol. VII, No. 37 (July-August 1926), p. 27.

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17) Ibid., pp. 507-509.

18) Harris, J.P. Picatinny Arsenal. (Dover, N.J.: Picatinny Arsenal, 1953), p. 13.

19) Campbell, The Industry-Ordnance Team, p. 41.

20) Encyclopedia of Explosives and Related Items. (Dover, New Jersey: Large Caliber Weapons Systems Laboratory, Picatinny Arsenal, 1978), Vol. VIII, p. 270.

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22) Ordnance School, Picatinny Arsenal. Ammunition, Powder and Explosives Course II. (Dover, N.J.: Picatinny Arsenal, 1940), Vol. II, Sect. VIII, pp. 1-15. "Loading and Assembling of Time Fuzes."

23) This section derived from: Ibid., Vol. II, Sect. IX 1, pp. 1-7, "Primers: Design and Functioning."

24) This section derived from: Ibid., Vol. II, Sect. IX 2 pp. 1-6, "Primers: Loading and Assembling Artillery Primers."

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400 AREA - GUN BAG LOADING DISTRICT

The Gun Bag Loading District (400 Area) lies on the southern shore of Lake Picatinny, just east of the Powder Factory (500 Area). The 400 Area is a large section of the arsenal containing buildings used for a variety of purposes. Only those 400 Area buildings used in the loading of propellant powder are discussed in this report. The 400 Area is bounded by Buffington Road and Lake Picatinny to the northeast, Babbit Road and 16th Avenue to the southeast, 11th Street to the west and the 300 Area to the northwest. Railroad lines brought powder from the powder plant and carried the filled bags to storage and shipping areas, and to the 800 Area.

400 Area Buildings

Bldg.	Function	Date
439	Change House	1948
445	Bag Loading	1930
445A-F	Storage Magazines	1918, 1930, 1942
448	Bag Loading: Howitzer and Aliquot	1930
448A	Storage Magazine	1930
448B	Rest House	1930
448C	Weigh and Mix	1942
448D	Storage Magazine	1930
452	Bag Loading Igniter	1942
452A-B	Storage Magazines	1930
454	Bag Loading: Howitzer	1930
454A-B	Storage Magazines	1941-2
455	Cloth Storage, dyeing, cutting and sewing	1930
462	Tracer Loading	1942
462A-B	Storage Magazines	1941-2
472	Change House	1957
472B	Hand Car Storage	1947

The gun bag loading area was constructed in the late 1920's and early 1930's following the 1926 Explosion. Prior to the explosion, bag loading activities had been scattered around the post in warehouses. The decision to rebuild the arsenal provided for the construction of specialized bag loading facilities. As a result, the 400 Area consists of structures uniquely designed for the handling of large quantities of propellant powder.[1] The gun bag loading section of the 400 Area consists of 20 buildings, comprising five major assembly units and a number of support buildings. The majority of the buildings are of 8 inch hollow red tile construction.

Firing an artillery weapon requires three basic items: a weapon, a projectile (the item being fired) and a propellant (the explosive that propels the projectile). The earliest propellant was black powder, but in the late 19th and early 20th centuries it was largely replaced by nitrocellulose. To use nitrocellulose as a propellant, it was necessary to develop a system of loading the powder into bags, and then attaching a primer and detonator to initiate the explosion. Different types of guns required different amounts of propellant powder, bagged in various sizes, to operate properly.

At Picatinny Arsenal bag loading of propellant powder began before the Spanish-American War and continued until the Vietnam conflict.[2] During the early 20th century nitroglycerin powder, black powder, and brown prismatic powder were all used as propellant.[3] Silk bags which held the powder were sewn at the arsenal and, in case of emergency or rush orders, local women would assist by sewing bags at home.

Propellant Loads

A propellant charge consists of an igniter, usually black powder, and one or more units of nitrocellulose powder. Ammunition is assembled for firing in three forms: fixed, semi-fixed and separate loading.

Fixed - A total unit, with the projectile and propellant joined in a brass cartridge. This type is generally used in guns up to and including the 105mm gun.[4] The main drawback is that the load cannot be changed, thus allowing for only a single firing zone.

Semi-Fixed - The propellant is loaded into a brass cartridge, but it is not firmly attached to the projectile. The propellant in the cartridge is bagged into a number of separate bags so that the load can be adjusted for zone firing in the field. Semi-fixed rounds are used in howitzers and mortars up to and including the 105mm howitzer.[5]

Separate Loading - Whereas in fixed and semi-fixed ammunition the propellant and the projectile are loaded into the breech of the gun as a single unit, in separate loading the projectile is first placed in the breech and then a number of bags of powder are loaded behind the shell. Separate loading is divided into zoned and unzoned types. Separate loading is used in larger guns, howitzers and mortars.[6]

Zoned types of loads can further be divided into increment charges, aliquot part charges, and base and increment charges.

Increment Charges - In all zoned charges, the weight of the charge is divided into several parts to insure a high angle of fall:

> "[Increment] charges are assembled in such a manner as to allow for their disassembly into their separate increments, at the time of fire...It has been found that the accuracy of fire in the lower or inner zones (reduced charge) is materially reduced from that obtained with the full charge as in the higher, or outer zones....In order to eliminate the erratic behavior given by the lower zones of certain increment charges, in their respective weapons there have been provided two separate charges, one for use in the inner zones and one for use in the outer zones, these charges containing powders having different quickness. An example of this type of charge is found in the propelling charges for the eight inch Howitzer Mod. 1920 M1E1...These (T3) charges are loaded with a powder of finer granulation to provide faster burning, in order to give higher pressures and hence greater accuracy of fire for the inner zones. The second charge (T4)...consists of a base zone and two additional increments. These (T) charges are loaded with a slower powder than is used in the T3 charges in order that the pressure limit for the weapon is not exceeded in the outer zone firing."[7]

Aliquot Part Charges - In the aliquot part charge, the powder load is divided into several bags of equal weight and equal powder type. The igniter pad is added to the last bag loaded into the breech. For some guns (e.g. the 240 mm howitzer), an unequal aliquot part charge was developed.

Base and Increment Charge - This produces a two part charge, a base consisting of seven-eighths of the total powder charge and an increment containing the remaining one-eighth powder charge. This type charge was designed to reduce wear and tear on gun barrels when a full charge is not needed.

Unzoned type loads can be divided into single or multiple section charges.

Single Section Charges - Medium caliber guns usually use a single section charge. In larger guns it is unwieldy - a 16-inch gun requires almost 800 pounds of powder and a single section charge would be almost eight feet long.

Multi-section Charge - This is basically a single section charge divided into equal parts for ease of loading.

Igniter pads

Pulling the lanyard of a gun will not fire nitrocellulose powder. However, black powder, which can be ignited by electricity, a spark, or friction can, in turn, ignite nitrocellulose powder, thus firing a gun. In fixed and semi-fixed ammunition the same ignition system is used and the primer is placed at the base of the cartridge. In the case of semi-fixed ammunition an additional amount of black powder is placed in the cartridge, usually in the form of a small ring of black powder. This compensates for the silk bags that the propellant powder is placed in prior to loading in the cartridge case.

> "In the case of all increment, base and increment, and single section charges the igniter pad is made an integral part of the powder bag and cannot be detached while in the case of the aliquot part and multi-section charges The igniter is made as a separate unit and is attached to the base increment or section as the case may be. This pad, which is dyed red for identification purposes, is loaded with black powder, which is readily ignited by either the electric or friction primer, used in these weapons employing separate loading ammunition, and thereby provides the ignition for the propelling charge."[8]

One major problem with loading propellant charges was that of loading propellant into a bag and securing it shut while also ensuring that it would fit within the barrel of a gun. Another problem concerned the wrapping of a charge so that the gases from the primer could not flow properly through the charge.

Bag Cloth

The type of cloth used to make a powder bag was of critical importance. The cloth had to be very strong, resistant to stretching, resistant to puncture, and capable of burning completely when fired. Inability to burn completely could result in embers left in the barrel which could prematurely ignite the next charge loaded into the breech.

Raw silk was the fabric of choice for powder bags. It had maximum strength, minimum stretch, low weight and low bulk. Silk, being an animal fiber, did not smoulder like vegetable fibers. However, during times of war, silk was often in short supply. During World War I experiments were conducted with wool and mohair for powder bags, and they were used to some extent. At the same time, DuPont developed a cloth called nitrotite which was both waterproof and completely consumed in firing. However, the war ended before full testing of the cloth occurred, and its development halted.[9]

Between the wars, researchers sought a cotton fabric to replace silk cloth and, despite the smoulder problem, it was believed that in bags where the ratio of powder to cloth was quite large, the burning of the powder would consume all the cotton. All knots and tie straps on the charges had to be made of silk because it was believed that knotted cotton would not burn completely.[10]

Prior to the 1926 Explosion, powder charge loading was done in warehouses. Since these facilities were not designed for this work, too many operations were performed too close together, creating safety problems. The development of machinery to assist in the loading of bags was also a major concern.

> "During the early stages of the [First] World War Maj. J. H. Meyers developed a bag wrapping machine which revolutionized the bag loading operations. Prior to this time it was customary to have the bag made considerably larger in diameter than was necessary and then by the use of lacing twine the charge was tightened so as to make it rigid. This bag wrapping machine permitted the bags to be made approximately the exact size required. The charge was then wrapped with putteeing tape about 2 inches in width. This practice used slightly more cloth per charge, but did not prove to be a drawback to the method as it permitted the use of a much lighter grade of silk cloth in the side walls of the bag because of the extra strength given by the tape, which actually worked out as a saving in money. By the use of this machine, production per operator was increased about eight times. It is believed that had not this machine been developed, considerable difficulty would have been encountered in obtaining, first, the production of the laced type silk bags themselves, and secondly, the production required in the number of charges."[11]

Rebuilding the Arsenal

After the 1926 Explosion, the Army redeveloped the bag loading operations, concentrating activities in structures built specifically for these purposes. For the first time, safety features were considered and bag loading activities were placed in carefully segregated and barricaded areas. With the rebuilding of the bag loading facility as an integral unit, all activities were grouped according to need. Three bag loading buildings (445, 448 and 452) were built in a line along Whittemore Avenue. In each building the powder was hoisted to the top of a hopper tower and distributed to individual loading rooms by means of galvanized tubes. Safety measures controlled the amount of powder moving through the tubes, thus limiting the possibility of flashback if a blow occurred in any loading room. For example, Building 454, on 16th Avenue was a two story structure in which each filling room was directly under its own storage room. The powder was passed from the second floor to the first where it was loaded into bags and the central hall was used to add igniters, and then sew and wrap the bags.

Built in 1930, Building 445 was a general bag loading building used for those sizes not covered by the other buildings. Building 448 was built in 1930 to load powder for howitzers and to load aliquot part charges. Building 452, built in 1942, was designated specifically for the loading of igniters. Building 454 was constructed in 1930 to load howitzer charges. Building 462 was built in 1942 to load tracers, while Building 455, the cloth storage, dyeing, cutting and sewing structure, was built in 1930 specifically to prepare the bags for loading. During World War II, as many as 500 sewing machines were used to produce silk and cotton bags.

Loading A Bag

Bag loading of propellant powder was carried out in the 400 Area from 1930 to 1974. During that time the type of bag being loaded changed from silk to cotton, to polyester. At the same time, the type of powders being loaded changed as the technology of powder production developed. Methods of loading powder also changed over the course of 44 years. The following descriptions of bag loading include:

Bag loading in Building 448, circa 1935.

Loading expulsion powder into polyethylene bags (M10 powder), 1962.

Sewing the filler opening in base igniters, 1972.

Bag loading for the 155mm Howitzer, 1974.

Bag Loading in Building 448, Circa 1935

Powder arrived at Building 448 from storage via railroad lines. Cannisters of powder were dumped into the elevator car, which was built of wood and rubber lined on the inside and aluminum clad on the outside. Wooden rails controlled the motion of the car as it was raised to the top of the building; at the top, the powder fed directly into two powder hoppers by chutes from the elevator car. Safety chutes led from the elevator tower to the ground. Eight five-inch powder transfer pipes directed the powder from the hoppers to the eight loading rooms on the first floor. The pipes were galvanized metal covered with one and one half inches of magnesia, one inch of hair felt, and two ply rubberoid. The eight loading rooms were separated as a group from the rest of the building by heavy reinforced concrete fire walls, and from each other by six-inch hollow tile walls. The rooms opened to the outside of the building with blowout doors. Connection with the central hall was achieved only by transfer chutes that could not be opened from both sides at the same time.

Each loading room contained a scale table, a filling table, a sewing table and a transfer chute. Powder entered the room through the transfer chute. The amount needed was measured out on the scales, and poured into a pre-sewn bag. The operator sewed the final seam and transferred the filled bag into the central hallway. From there it was moved to the tying and assembly area to be turned into the complete propellant charge. In the case of aloquit part charges, the parts were tied together and the igniter added before being wrapped or inserted into a cartridge case.

Safety was of critical importance in the bag loading building. Besides the construction of reinforced concrete firewalls, and blowout doors, all metal items in the loading room were grounded in order to reduce the danger of a static charge igniting the powder. Lightbulbs were placed in explosion proof fixtures to reduce the danger from shorted or shattered bulbs. The number of people allowed in each of the loading rooms was limited to one operator and a transient supervisor. Any bags that were not filled to the proper weight were rejected and the powder was removed for reuse. Sewing machines used needles made of spark-proof metal.

The problem with sparking needles, or needles striking powder during sewing, is best illustrated by an accident that occurred at 11:50 a.m. on November 16, 1916. Five women sewing machine operators were burned, three seriously, when an explosion was started by a broken needle that struck the igniting powder being quilted into the end of a 12-inch gun cartridge bag. The explosion of the ignition powder initiated the explosion of about three pounds of powder in cartridge bags located at that machine. Those explosions, in turn, caused the explosion of powder located at four other sewing machines located in the room, some 12 to 14 feet away. This took place in a building used for loading before the construction of the new bag loading plant in 1930. As a result of such accidents, provisions were made in the new plant so that no more than one sewing machine was placed in a loading room, thus limiting the possibility of sympathetic explosions.[12]

Loading Expulsion Powder into Polyethylene Bags (M10 Propellant), 1962

By 1962, polyethylene bags and heat sealing had been introduced at the arsenal. The following description is taken from the operation data sheets located in each loading room and at each activity site.[13]

In Building 455, powder was sent down to each loading room from a separate storage room directly above it. For the weighing of the expulsion charge, the operator had on hand a supply of powder bags sealed at one end, two Shadow-graph 4 oz. capacity scales with scoops, several conductive rubber receptables, cotton rags, a red safety can, a set of weights, tared containers, and a flash shield. Powder was received from the supply operator in amounts limited to three pounds. 65.0 grams +/- .25 were measured out and placed in a tared container and passed on to the next operator. Scales were checked every two hours.

At the next operator all charges were again weighed, with rejected charges returned to the preceding operator for correction. A funnel was inserted into the open end of a bag and the powder was slowly poured into the bag. Filled bags were placed in a cuspidor for transfer to the next operation. If any powder spilled, that charge was rejected. Any unspilled powder in the bags was returned to the original supply container. Spilled powder was wiped up immediately with a water dampened rag and then disposed of in a red step-on safety can partially filled with water.

The heat seal operator received the loaded bag from the previous operation and placed a cellophane strip around the area of the bag to be sealed. After sealing, the bag was inspected for gaps in the seal. Resealing was allowed. The heat seal was accomplished at a temperature of not more than 375° F., with a maximum sealing time of six seconds. The temperature of the head seal was checked each hour and an inspector checked all sealed bags for continuous unbroken seals.

Sewing Filler Opening in Base Igniter, 1972[14]

Sewing the filler opening in a bag was a one-person, isolated room task. Black powder, used in the igniter, could not be heat sealed as could the propellant powder. Equipment included: one Singer Type 1716 sewing machine with locating gauge, phosphorous bronze no. 18 needles, a red safety can, a red wooden reject tray, a non-sparking metal dust pan, a camel hair brush, and a thread cutting fixture attached to the sewing machine. Filled bags were received from the previous operator and sewing thread was received from the supply operator. The first step was to inspect the bag to ensure that the sewing area was free of powder. The bag was positioned with the powder opening under the needle of the sewing machine with the corner of the bag aligned into the corner of the locating gauge so that the machine would sew the opening. Incomplete seams were resewn. Finished bags were placed in a chute for transfer to the next operation.

Safety precautions focused on making sure that the needle never came into contact with any powder. Care had to be taken that no powder was spilled. If powder did spill from a bag, that bag was to be placed in the reject tray, while spilled powder was wiped up and dumped into the red safety can. No more than 10 assemblies were allowed to accumulate in a room at any one time.

Bag Loading for the 155mm Howitzer, 1974-1976[15]

By 1974, certain elements of the 155mm howitzer propellant powder bag were being constructed of resin impregnated spun viscose rayon. Specific diagrams were prepared to detail the complicated construction of the powder charge bag, whereby each element was located in a separate bag and all bags were sewn together, except in the case of zone fire charges. Several different flash inhibitors were being used, and if one or more was being tested in a bag it had to be separately loaded and attached to the powder charge.

In the case of the 155mm charge, the directions for the operators had become much more complete and specific. Diagrams were now being provided for the operators in addition to written instructions. For example, the instructions for tying together the completed charge included both drawings and written notes on the tying process.

As of 1984, powder was no longer loaded in the bag loading district of the arsenal, although the machinery is still in place in Building 455, and the capability does exist to resume the loading of charges. Building 462 was being used for non-related research, and Buildings 445, 448, and 452 were being used for miscellaneous storage. There are no plans to resume the loading of propellant powder charges in those buildings.

<u>400 Area Footnotes:</u>

1) Hare, Ray M., "Building Safety into an Explosive." <u>The Quartermaster Review</u>. (Nov.-Dec. 1930): p. 46.

2) <u>Encyclopedia of Explosives and Related Items Vol. 8.</u> (Dover, New Jersey: Large Caliber Weapons Systems Laboratory, Picatinny Arsenal, 1978), p. 268.

3) Tschappet, William. <u>Textbook of Ordnance and Gunnery</u>. (New York: John Wiley and Sons, 1917), pp. 11-13.

4) Brayton, H.M. "Complete Rounds of Ammunition: A Discussion of Improvements to Meet Tactical Demands." <u>Army Ordnance</u>. Vol. IX, No. 52 (January-February 1929), p. 264.

5) Ibid.

6) Ibid.

7) <u>Ordinance Officers Course # 2</u>, (Dover, N.J.: Picatinny Arsenal, 1942), Section IV, p. 6.

8) Ibid., p. 9.

9) Hayes, Thomas J., <u>Elements of Ordnance</u>. (New York: John Wiley and Sons, 1938), pp. 34-35.

10) Harris, J.P., <u>Picatinny Arsenal</u>. (Dover, New Jersey: Picatinny Arsenal, 1953), p. 6.

11) Harris, John P., "Loading Ammuntion at Picatinny Arsenal," <u>Army Ordnance</u> Vol. VII, No. 37, (August 1926), p. 42.

12) War Plans Division, Plant Engineering Department. <u>The History of Picatinny Arsenal</u>, Vol. 1. Picatinny Arsenal, N.J. (1931; Reprint Ed., Facilities Engineering Division, 1976), p. 106.

13) Operations Data Sheet, File No. 24-14-54, Picatinny Arsenal, Arsenal Operations Division.

14) Operations Data Sheet, File No. 33-1-127, Picatinny Arsenal, Industrial Services Directorate, 2 October 1972.

15) Assorted draft specifications for the propelling charge for the 155mm Howitzer, XM198, M109A1, dated 27 February 1974 to 12 April 1976.

500 AREA - POWDER FACTORY AND POWER HOUSE DISTRICT

The Powder Factory and Power House District (500 Area) is a collection of approximately sixty buildings located on the south and southwest shore of Picatinny Lake. Willis Street to the northeast separates the 500 Area from the storage magazines of the 900 Area. Boot Road to the west separates the Powder Factory from Navy Hill, the former Lake Denmark Powder Depot. The 400 Area bag loading facility is separated from the Powder factory by Whitmore Avenue. The 500 Area is relatively flat, rising from the lake towards Willis Street and no creeks or streams run through it.

The powder factory was authorized by the Army in 1906. Following the explosion at the Navy's Lake Denmark Powder Depot in 1926, the factory was reorganized using new technology. More rebuilding followed the destruction of the cannon powder blender in 1928. The majority of the buildings in the area are of eight inch hollow red tile construction. However, auxiliary and temporary buildings built during World War II were usually built of wood and galvanized steel. Where danger from sparks of static electricity was greatest, special consideration was given to construction techniques. When thought to be desirable, doors, windows, equipment, and even people were grounded so that electrical problems could be minimized.

Activities in the powder factory involved the use of hazardous chemicals, the creation of dangerous compounds, and the disposal of toxic wastes. As a result, the buildings of the powder factory are considered to be highly contaminated. Because cleanup costs are considered prohibitive, as of 1983 the burning of many 500 Area buildings had already begun.

Building 506 is the Picatinny Arsenal power plant, originally constructed in 1907 and rebuilt and enlarged in 1956. The power plant not only provided the electrical power needed by the arsenal but also the steam used in the production of powders, operation of machinery, and heating of buildings.

The powder factory was serviced by a series of rail lines, both standard and 3-foot narrow gauge. Where dual gauge lines run, there is the normal three rail dual gauge line, as well as a four rail system. Though no longer used, small fireless steam powered locomotives once pushed car loads of chemicals and powder throughout the factory.

500 AREA BUILDINGS

Building	Function	Date
501	Area Maintenance	
506	Power House	1907/1956
507	Railroad Engine Shop	1924
507A	Change House	1941
507B	Office	1942
509	Cotton Storage	1930
510	Cotton Picker & Dryhouse	1930
511	Nitrating House	1919
514	Boiling Tub House	1930
519	Ether & Alcohol Recovery	1908/1930
519A	Alcohol Storage	1941
520	Poaching House	1943
520B	Nitrocellulose Resthouse	1922
521	Ether Vault	1909
523	Inert Gas Manufacturing	1938

Building	Function	Date
524	Change House	1956(?)
525	Control Lab/Change House	1930
525A	Acid Laboratory	1930
527	Powder Factory	1929
533/534	Solvent Recovery	1941/1930
535	Recovered Solvent Storage	1910
537	Dryhouse	1918
539	Small Arms Powder Blender and Packing House	1930
541	Water Dry House	1943
524	Dry House	1942
542B	Change House	1930
545	Packing and Testing	1928
550	Nitrocellulose Storage	1918
550A	Bombproof Shelter	1921
553	Ether & Alcohol Storage	1942
554	Water Dry House	1930
555/556	Dry House	1930
556A	Control House	1930
557	Double Based Coating and Glazing	1930
558	Dryhouse	1931
561	Powder Blender	1931
562	Transfer Building	1931
563	Glazing Building	1931
564	Box Test	1931
565	Pack House	1931
566	Screening Building	1931
567	Resthouse	1931
577	Screening and Sorting Building	1931

Perhaps the greatest misconception to overcome when dealing with the development of nitrocellulose propellant powder, is the word "powder." Nitrocellulose propellant powder is not a fine powder but a coarse grain ranging in diameter from 1/8th inch to more than one inch. Length exceeds diameter and the grains are perforated with one hole for the smaller sizes and seven holes for the larger sizes. The grains are formed by forcing paste through dies and cutting it to length. Each type of projectile required its own propellant powder. Picatinny Arsenal was involved in the development of dozens of powders, each of which had to be uniform, with unvarying performance characteristics.[1]

The powder factory at Picatinny Arsenal was begun in 1907, with an original appropriation of $77,000. By 1916, the basic buildings had been completed and a regular production schedule was being maintained.[2] During those years of development, powder production increased from 3,000 to 9,000 pounds per day.[3] During World War I, Picatinny Arsenal was the initial American producer of propellant powder (producing all sizes from .30 caliber to 16 inch), though the total amount produced was but a fraction of that produced throughout the United States by the end of the war.

Between wars the production of powder declined as existing stocks of powder were consumed through use, deterioration, or accidental explosion. In 1919 the powder factory was renovated and new experimental labs were developed.[4] The 1926 Explosion destroyed several buildings within the powder plant and damaged most of the other buildings. In the course of rebuilding, the decision was made to discontinue the nitration of cotton at the plant, and subsequently nitrated cotton was purchased from Hercules and Du Pont. In 1928, the powder blender built by Col. J.C. Nicholls was destroyed in an explosion and fire. Col. Nicholls' blender was unlike the ones presently on site. As opposed to the existing blending towers in which the powder is hoisted to the top and then dropped through a series of inverted pyrimidal bins, the Nicholls blender consisted of two towers with one inverted pyrimidal bin in each. The bin of one tower was charged from the ground floor of the other by means of belt conveyors.[5]

Picatinny Arsenal was the first American facility to produce propellant powder at the beginning of World War II, but its total production was only a small portion of the U. S. total produced during the war. Following the war, production again declined until the need for powder increased during the Korean and Vietnam conflicts. After 1970, production slowed again and some machinery was moved to other areas of the arsenal. By 1983, production in the 500 Area had completely ceased.

Production of Nitrocellulose Propellant Powder

Very few records on the production of powder at Picatinny Arsenal survive. As buildings within the powder plant were closed, records were left unattended and many buildings have been burned with their records still inside. As a result, the following description of the production of powder is based on fragmentary sources. Powder was produced at the arsenal for use in .30 caliber rifles through 16-inch guns and, though each type of powder required different ratios of chemical compounds, the following description of the production of medium size cannon powder is representative of such work in general.

Preliminary Processing

Nitrocellulose propellant powder is produced by the nitration of cotton. During the early years of production at Picatinny Arsenal, the nitration of cotton was conducted on site. Bales of cotton were stored in Building 509, picked and dried in Building 510 and nitrated in Building 511. Initially, nitration of cotton was done with the Thompson displacement process. In this process, the dry cotton was immersed in a solution of nitric and sulphuric acids. To separate the cotton from the acid following nitration, water was added to the top of the nitrator while the acid was drawn off at the bottom at a similar rate. This ensured the retrieval and reuse of most of the acid used in the process. The DuPont centrifugal nitrator, which used less water but preserved less acid, later replaced the Thompson process. After leaving Building 511, the nitrated cotton was taken to Building 514 where it went through a series of boilings to remove the residual acid. After the arsenal began to purchase nitrated cotton from outside sources, the boiling tub house became a general experiment building, used as needed. Buildings 509 and 510 became storage buildings.

The Poaching House: Bldgs. 517 and 520

Dumping: Nitrated cotton with a water content of 20% to 35% was received from Hercules and DuPont in galvanized cans of 200 to 236 pounds net wet weight. The dumping operation added water to the nitrated cotton, forming a slurry which was easier and safer to handle. Within the dumping area only 60,000 lbs. of explosive were allowed at any one time, and during operations only 6 operatives were permitted to be on site. All tools used to open and dump the cans were composed of copper-beryllium. Upon opening a can, water was immediately added to prevent the flashing of dry nitrated cotton. After being wetted down the can was dumped into an agitator, with one load consisting of 60 cans.

Settling and Decanting: The slurry from the agitator was moved to wooden settling and decanting tubs. Here the slurry sat for at least 45 minutes before being decanted. Decanting removed all water soluble and lighter-than-water impurities in the solution. 150,000 lbs. of explosive and 12 operatives were allowed in the room during the process. No metal tools were allowed, only straw brooms and hoses to wash down the tubs.

Screening and Riffling: In order to ensure that all foreign material was removed from the slurry, it was passed through a brass screen to remove large particles, and then passed through a riffle box to remove small dense particles by both settling and magnetic separation. 1,000 lbs. of explosive and 4 personnel were allowed in the room during the operation. Only wooden and rubber tools were allowed. At all times, clean water was first passed through the equipment to ensure that any residual nitrated cotton was wet before any action took place that could result in a detonation.

Wringing: The wringing operation consisted of centrifuging the screened nitrated cotton slurry in a basket-type centrifuge to give a fluffy mass of nitrated cotton containing about 30% water. One wringer load contained about 170 lbs. of dry weight cotton. Explosive and personnel limits were the same as for screening and riffling. Only wooden and spark proof tools were allowed in the room.

Collection: While the water content of the nitrated cotton was being determined, it was stored in aluminum cans, thus freeing the wringer for further use. Empty narrow gauge railroad cars were placed beneath the wringers and the nitrated cotton was dumped and tamped down. 18 wringer loads were placed in each car. After being filled, samples were drawn, a tarpaulin was placed over the car, the floor and tracks were hosed down, and the car was stored in Building 552.

Sampling: To determine the water content of the nitrated cotton, samples were taken from predetermined places in each car. A brass thief was rammed into the nitrated cotton, and a sample was removed and placed in a fiber container. Samples 1 to 4 were taken one foot from each corner of the car. Samples 5 to 8 were taken one foot from the side, midway between corners. Sample 9 was taken from the middle of the car. All nine samples were mixed in the fiber container. From the container a 2-quart glass jar was filled and sent to Building 525 for testing.

Testing: The sample of nitrated cotton was taken to Building 525, dumped into an aluminum bowl and blended by hand. A tared sample can was filled and weighed. The can was placed in a heated chamber and dryed for 10 minutes at

$55-65^{o}$ C. The can was weighed again and the percentage of water was determined by the formula: percentage of water = Ww - Wd/Ww X 100 where Ww is the weight of wet nitrated cotton and Wd is the weight of the dry nitrated cotton.

The Powder Factory: Bldg. 527

Dehydration of Water Wet Nitrocellulose: While nitrated cotton has to be "wet" while being processed, water must be removed at the beginning of the process to ensure the non-hydroscopicity of the smokeless powder. In the dehydration process water was replaced by alcohol. This was done by placing the nitrated cotton in a hydraulic press and forcing in alcohol, which in turn forced out the water. 4,500 lbs. of water wet nitrated cotton and 1500 lbs. of alcohol wet nitrated cotton and 6 operators were allowed in the dehydration room. The nitrated cotton arrived at the dehydration room in aluminum cars from Building 552. Once the moisture content was determined, calculations were made to determine how much wet cotton was to be placed in the press to produce a block of 27.777 lbs. of dry nitrated cotton. Nine blocks of nitrated cotton made up a 250 pound mix, and they were placed on a buggy for transfer. All tools used were of wood or brass.

Ether Mixing (Room 2): Large size cannon powder contained diphenylamine and it was necessary to mix this substance with ether before adding it to the nitrated cotton.

DNT Screening (Room 1) Bldg. 521: Dinitrotoluene is used in some cannon powders (M1, M6, and M14). DNT screening operations produce the very fine particles of DNT used. The building also processed the DNT used in double-base powders produced in the 1300 AREA of the Arsenal. The DNT was screened in small batches of 15 lbs. each. DNT is hazardous both on the skin and if ingested. Workers were not allowed to bring food into the building, or to chew gum or tobacco. Skin had to be covered at all times and clean clothes were required for each shift. Workers were required to shower at the end of each shift.

Mixing (Rooms 3, 4, 6, 7, 26, 27, 29, 30), Bldg. 527: To form a colloided paste, the nitrocellulose, alcohol, ether, DNT, potassium sulfate, DPA, and DBP were mixed together. Each water jacketed mixer built by the Baker-Perkins Co. had a 150 gallon capacity. A buggy with nine blocks of dehydrated nitrocellulose was moved to a mixer room, the mixer was turned on and each block was added one at a time. After all nine blocks had been broken up, the mixer was stopped and appropriate amounts of alcohol, potassium sulfate and/or DNT were scattered over the top of the nitrocellulose. The mixer was turned on again for 15 minutes. Then mixed ether was added while cold water circulating in the jacket of mixer held the temperature to 20^{o}C +/-1 degree. After 60 minutes of running, the mixer was stopped, the sides scraped down with a brass scraper, and the mixer run for an additional five minutes. Using a aluminum hoe the mixture was scrapped into three aluminum containers in front of the mixer. Cannon powder (M1, M6, and M14) was sent to the macerator, while rifle powder (M10) was sent to preliminary blocking. Only 300 lbs. of explosives were allowed in each mixing room at any one time.

Remix Scrap Powder, Bldg. 527: Each operation produced scrap materials left in machines or spilled onto the floor. Remixing allowed for the recovery of much of that material. Using mixers, scrap material is added to fresh, usually at a rate of approximately 25 lbs. per mix.

The Weigh Room (Room 28), Bldg. 527: The weigh room weighed both ether and potassium sulfate and sent it by pipe to the mixers.

Macerating (Rooms 8,9,24,25), Bldg. 527: The macerating room reduced the size of the nitrocotton to allow more even distribution of solvents and thus more completely colloid the nitrocellulose. The four macerators were water jacketed, with geared pulley drive, and were built by the Read Machinery Company. Nitrated cotton from the mixers was loaded into the macerators and allowed to run undisturbed for 10 minutes. Metal drums were placed in front of the macerator, the front was opened and brass rakes were used to pull lumps of colloided material from the rollers of the macerator. Material not easily reached was left in the macerator until the end of the shift. Scrap material was returned to the scrap room and was not immediately readded to the macerator.

Preliminary Blocking (Room 10), Bldg. 527: Preliminary blocking prepared the mixed powder for the screening presses. Two unit presses, hydraulic and vertical, manufactured by the A.B. Farquahar Ltd., were filled with powder taken from cans.

Using low pressure, the ram was raised until the charge was close to the top of the press. The high pressure valve was then opened slowly to let air escape from the press until the pressure reached approximately 3,500 pounds. It was held at this pressure for one minute. The high pressure valve was shut off, the release valve opened, the head of the press opened, the release valve shut, and the low pressure valve opened to force out the block of powder from the chamber of the press. The block was removed from the press and sent to screening. A maximum of 600 lbs. of explosives and 8 operatives were allowed in the room at any one time. Safety precautions included keeping the assembly free of powder and making sure that a pressed charge was not reblocked.

Screening (Room 10), Bldg. 527: This room was used for screening, preliminary blocking, and final blocking. Screening removed uncolloided nitrocellulose and any other "oversize" material from the colloided paste. Five horizontal, hydraulic unit presses from the Watson-Stillman Co. were used. Two blocks of preliminary blocked powder were placed in the chamber of the screening press, followed by a sealing ring and 12-, 24- and 36-mesh screens. The low pressure valve was opened, forcing powder into the chamber against the sealing ring and screens. The low pressure valve was closed and the high pressure valve opened, letting the press come up slowly. After screening 50% of the powder, the high pressure valve was closed. A sliding knife on the head of the press was used to cut off the strands, and the high pressure valve was reopened and screening allowed to continue. When the screening was completed the pressure was shut off, the strands cut, and the press opened. Screens were removed and set aside to be cleaned by burning. Hard powder was removed with a brass scraper.

Final Blocking (Room 10), Bldg. 527: Final blocking was carried out with the same type of presses used in the preliminary blocking, the purpose being to remove trapped air and uncolloided cotton from the paste, thus preparing it for the finishing presses. Powder was received from the screening presses and placed in the chamber. The release valve was closed, the low pressure valve opened and the ram raised until the powder was close to the top of the chamber. The low pressure valve then was closed and the head of the press closed and locked. The low pressure valve was reopened and the head was brought up slowly and then closed down. The high pressure valve was then opened slowly until the pressure reached a maximum of approximately 3,500 lbs. It was held at this pressure for two minutes. After shutting off the high pressure valve, the release valve was opened, the head of the press was opened and the release valve closed. Using low pressure, the block was forced from the chamber and placed on a transfer buggy. All tools used were of brass or rubber.

Finishing Press (Room 12), Bldg. 527: The purpose of the finishing press was to produce formed grains of colloided powder with perforations and dimensions as required. The four horizontal, hydraulically powered presses used were manufactured by A.B. Farquahar Ltd. After cleaning a press, the perforated plate and die were set into the head of the press. Two blocks of powder were placed in the chamber of the press and the low pressure valve was opened to bring powder near to the end of the press. After locking screens and distributors in place, the powder was brought the rest of the way against the sealing ring and screen. Low pressure was shut off and high pressure opened, thus forcing the powder out of the end of the adapter. Fiber containers were placed under the chutes of the distributor and high pressure applied slowly to extrude the powder through the dies, down the chutes and into the fiber containers. At the conclusion of the process, the pressure was shut off, the powder strands were broken off near the top of the distributor and the head unlocked and opened. Screens were burned as before, and sealing rings were cleaned before recharging the press. All tools had to be of wood, brass or rubber.

Cutting (Room 14), Bldg. 527: Using three McKiernan-Terry Corporation continuous cutters, the end of the continuous strand of powder was inserted into the cutter, and powder cut to the desired length. The cut powder grains were then dumped into solvent recovery cans.

Solvent Recovery: Bldgs. 533 and 534

Aluminum cars were filled with cut powder, sealed shut and moved from the powder factory to the solvent recovery building. Here, each car was placed in a separate rooms and hoses were attached to the side and top of the cars. Warm air was circulated into the car from the side and the ether and alcohol vapors escaping from the powder were drawn out of the car at the top and sent to Building 519, the ether and alcohol recovery building, where the vapors were separated and sent to storage tanks. The amount of time spent in solvent recovery varied with the size of the grains of powder.

Water Drying: Bldgs. 541 and 546

The purpose of the water-drying operation was to remove clusters, remaining solvents, and case-hardened grains. The solvent recovery cars were sent on flat cars from Building 533/534, pushed by hand into the dumping room, and connected to grounding cables. Water and the powder were run into a preliminary hopper and screened to remove any discolored grains of powder. Powder from four to six solvent recovery cars was dumped with water into a large cypress tank. The water was heated to 65° C. and held at that temperature. The length of treatment time varied with the size of the powder grains being treated. When treatment was completed, water was drained from the tank, and the powder was loaded into screen bottomed cars which were moved in lots of eight to the air drying building. A maximum of 250,000 lbs. of explosive in water (10,000 lbs. out of water) and 12 operatives were allowed in Building 541 at any one time. Only 10,000 lbs. of explosives and 6 operatives were allowed in Building 546 at any one time.

Air Drying: Bldg. 542

The purpose of the air drying operation was to remove the moisture from the water-dried grains of powder. Eight cars of water wet powder were pushed into the Air Dry House, four on each track. The engine was removed, the cars uncoupled and lined up by hand under the drying ducts, and the rubber coupling clamped into place on top of the cars and to the openings in the side of the cars. Blowing fans and suction fans were turned on, forcing warm air through the cars and around the powder grains. At the end of the drying operation, the powder was allowed to cool below 35^{o} C before the car was uncoupled and pulled to temporary storage bins in Building 559. Only 20,000 lbs. of explosive and 6 operatives were allowed in the building at one time, and no operatives were allowed in the building during the actual drying operation.

Bagging: Bldg. 559

The purpose of bagging was to place the powder in 100-pound units so that the graining charge could be more easily handled. After drying, filled powder cars were received from Building 542. Powder to be stored temporarily was moved to the top floor and the cars grounded near the bin to be filled. After dumping powder into the bins, the cars were returned to the dry house. On the lower floor, bags were placed on the scales and powder funnelled from the second floor bins into the bags on the scale. The top of the bag was secured with a heavy cord, the bag was loaded onto a trailer, and the filled trailer was moved by locomotive to the glazing building. The major precautions taken during bagging were to insure that all ground wires and connections were made tight before discharging the powder into the bins. Once the powder had been dried, the danger from static electricity was an ever present hazzard. Only 200,000 lbs. of explosives and 10 operatives were allowed in the building at any one time.

Glazing: Bldg. 557

The purpose of the glazing operation was to provide the grains with a graphited surface to act as a lubricant for loading. It also "sealed" the grain from moisture. The bags of powder to be glazed were unloaded and stacked near the glazing barrel. Powder was dumped into the barrel along with one tenth of a pound of graphite per 100 pounds of powder. After all personnel had cleared the building, the control switches were turned on from behind barricades. The barrels revolved for 45 minutes. At the end of the process the powder was reloaded into the 100 pound sacks. The trailer was then refilled and removed to Building 577 for screening. Safety precautions included locking the control switches in the "off" position during all charging and discharging operations, keeping personnel out of the building during the operation of the glazing barrels, and ensuring that all equipment was securely grounded. At any one time only 800 lbs. of explosive and 3 operatives were allowed in each of the glazing rooms, though no operatives were allowed in the room during the actual operation of the machinery.

Screening Glazed Powder: Bldg. 577

The purpose of the screening operation was to remove oversize and undersize grains from the glazed powder. A Robinson Manufacturing Co. shaker screen unit with two screens was used to remove unwanted grains. Glazed powder was received from Building 557, the hopper was filled and the remaining bags of powder were piled to one side. After checking the screen for foreign particles and broken screens, bolts, etc. cars were placed to receive the correct size of powder. The switch was then turned on. The cars of screened powder were moved by locomotive to temporary storage. Safety precautions included having all personnel leave the room during operations, securely grounding all equipment, and thoroughly wetting down all rail tracks before the cars approached or left the building.

Glazed Powder Storage: Bldg. 559

The purpose of the glazed powder storage was to accumulate sufficient screened glazed powder for a blender charge (e.g. 121,00 lbs. for 75 mm M10 powder). The powder was dumped into galvanized storage bins. When enough powder had been loaded in the bins it was placed in wooden dump buggies. These buggies were loaded onto flatcars to be moved by locomotive to the elevator in Building 561.

Blending: Building 561 and Building 539

The purpose of the blending operation was to produce a homogeneous mixture of the powder grains. The blender was a unique structure consisting of four floors with a hopper and funnel system to distribute and mix the powder as it fell through the building. Two dump buggies from temporary powder storage were removed by hand from the flat car and pushed across the explosion proof concrete platform into the elevator. The operator in the barricaded control house checked to see that the buggies were on the elevator and that everything else was clear of the elevator. At the top of the blender, the operators moved the buggies to the dumping pit, and connected the ground cable to the buggy before dumping the powder through the pit grating. The empty buggies were returned to the elevator and sent back to the first floor. The process was repeated until the entire lot had been dumped in the pit on the top floor. Then the operators descended and, except for the operator in the barricaded booth, left the building. After checking to see that all people had cleared the building, the operator turned cranks which opened gates at the bottom of the top blending cone, and immediately left for the packing building. The operator timed the blending operation for about 13 minutes. When all powder had fallen to the second bin, the operator returned to the operating booth, closed the bottom gate of the top bin and opened the bottom gate of the second bin. The process of opening gates and leaving the building was repeated from the second to the third and then to the bottom bin. Powder was removed from the bottom bin into aluminum dump trucks. One operator stayed in the room under the bottom bin to place the buggies while a second operator stood on the wooden platform and opened the gate to fill the buggies. The filled buggies were returned to the elevator and the entire process was repeated. Powder passed through the blender four times before being hauled to the packing building. Precautions included the grounding of all equipment and buggies, keeping people clear of the building and carrying out the blending operation only when the relative humidity in the blending building was above 60% (in the case of single perforated powder) or above 55% (in the case of multi-perforated powder). Ten operatives worked in the building until the actual blending began, then all personnel were required to leave.

Packing: Bldg. 565

Powder was packed for shipping into metal, wood or fiber containers. The most important tasks associated with this were the cleaning and proper labeling of the containers. All powder was then sent to storage where samples were drawn for testing before the powder was either sent to the 400 Area for loading or sent to other facilities.

SAFETY

Each section of the Arsenal's Description of Process for the Powder Factory placed major emphasis on safety. It contained numerous reminders to use sparkproof tools, grounded equipment, lots of water with nitrated cotton, etc. Despite all precautions, accidents did happen. The following incidents comprise a sampling of the types of accidents that occurred while handling powder.[7] Though these examples all occurred before 1930, they represent the types of dangers that existed in the 500 Area through the Vietnam conflict.

1. June 14, 1911. For unknown reasons, the top of the head of a dehydrating press was blown upward through the roof, landing 75 feet from the building, burying itself 2 feet in the ground. The foreman and two others were painfully burned.

2. September 6, 1916. Four operators were burned when a screw within a powder mixer caused a spark by scraping against the metal sides. This spark produced sufficient heat to ignite dehydrated pyro that had been placed in the mixer and was being fluffed prior to being mixed with ether.

3. February 22, 1918. The entire roof of the finishing press house was destroyed, the electric light circuits, motors, and sprinkler pipes were burned, causing $3,000 worth of damage. The neglect of an operator in adjusting a finishing press, and the neglect of an assistant foreman in allowing the cutters to become dirty was the cause of the fire.

4. March 11, 1918. A shed containing mixing and storage tanks was damaged when a fire was started by high pressure steam pipes placed against nitrated wood.

5. June 19, 1918. During the pressing of an extra long block of powder, some of the powder was pinched between the ram and the cylinder as the ram entered the cylinder. The accompanying friction caused a fire which destroyed 50 pounds of powder and damaged a motor and sprinkler heads. An operator was slightly burned.

6. August 8, 1920. The boiling tub house, beater house, and reworking mill (located in two adjacent buildings) were destroyed by a fire of unknown origin. The equipment lost included the boiling tubs, Miller Duplex and Jordan beaters, motors, an Allis Corliss engine, lathes, milling machines, shafting, settling equipment, etc. The original cost of the equipment was $72,228.00 and the estimated cost of replacing the buildings and equipment was $230,216.00. It was recommended that the various processes be rebuilt in separate buildings placed far apart, and that each building in the Powder Factory have an external cutoff of steam and electricity.

7. July 25, 1925. Sparks from an oxy-acetylene torch (used in boring a hole in a steel upright during the rebuilding of the pyro pit for catching pyro cotton from the Poaching House) ignited dry pyro cotton. This was in violation of Arsenal Safety Regulations which prohibit the use of such torches near explosive areas.

8. January 17, 1928. A fire of explosive violence damaged the mixing building and badly burned one man. The fire was caused when a mixer was charged with dehydrated, long fibered, unpulped pyro-cellulose cotton and some

of the alcohol deficient cotton got caught under the mixer blades and balled up. The resulting friction was sufficient to cause the combustion. Later recommendations specified that no dehydrated pyro cotton be allowed to sit long enough for evaporation of alcohol to occur before mixing; that the mixer blades be raised somewhat from the base of the mixer; and that a steel guard be placed between the mixer and the operator to deflect any hot gases resulting from a "blow".

9. July 31, 1928. The two Nicholls cannon blenders, the conveyor belts, a well house and paint shed, as well as 100,000 pounds of smokeless powder for 14-inch guns were destroyed in an explosion. The fire was believed to have been caused by the ignition of either powder dust or solvent along the conveyor by static discharge or friction. It was recommended that two conventional tower type blenders replace the one destroyed, and that they be placed sufficiently apart from each other to minimize the danger of fire or explosion damaging both.

500 Area Footnotes:

1) Smith, Ralph E. The Army and Economic Mobilization, United States Army in World War II: The War Department. (Washington, D.C.: Office of the Chief of Military History, Department of the Army, 1959), p. 8.

2) Miles, F. H., Jr. "The Picatinny Arsenal Powder Factory." Army Ordnance, Vol. VII, No. 37 (July-August 1926), pp. 9-10.

3) Encyclopedia of Explosives and Related Items, Vol. 8. (Dover, New Jersey: Large Caiber Weapons Systems Laboratory, Picatinny Arsenal, 1978), p. 268.

4) Ramsey, N.F. "Picatinny Arsenal." Army Ordnance, Vol. VII, No. 37 (July-August 1926), p. 3.

5) Miles, "Picatinny Arsenal Powder Factory," p. 11.

6) Picatinny Arsenal Powder Factory: Description of Process. (Dover, New Jersey: Picatinny Arsenal, n.d.).

7) War Plans Division, Plant Engineering Department. The History of Picatinny Arsenal, Vol. 1. (Picatinny Arsenal, N.J. 1931; Reprint Edition, Facilities Engineering Division, 1976), pp. 102-105.

600 AREA - TEST AREA DISTRICT

Located on the north side of Lake Picatinny, the 600 Area is the largest in the arsenal. It contains the buildings and testing areas used for the explosive testing of guns, shells, powders, explosives, etc. The testing of packing materials, jolt and jumble testing, etc., is done elsewhere in the arsenal. Bear Swamp Road and 20th Avenue run along the top of the ridge north of Lake Picatinny and the testing areas are spread out along the northwest sides of these two roads. Two small clusters of buildings are located at the southwestern end of the area. One of these groups houses the black powder factory, a facility that produced black powder for use in the fuze assembly lines and for use as an igniter in gun powder bags. Buildings 604 through 623 contain the testing chambers and control rooms used in the indoor testing of explosives.

The buildings in the 600 Area test zone were specifically designed to withstand shock and blast effects, and they were built in a variety of shapes and sizes. Exterior test zones look similar to a series of sand lot baseball fields, with light towers and open spaces. 600 Area buildings were built of wood, brick, concrete, galvanized steel or tile, depending on need. Specific construction features differed in line with the testing needs of each building.

Testing of both pure explosives and the products of the arsenal (e.g. shells, mortars, bombs, pyrotechnics, etc.) was always an important activity.

Prior to the 1926 Explosion testing activity took place all over the arsenal, often just outside the building where research was being conducted. As a result, numerous accidents and fires occurred within the production areas. Much of the testing was moved to a small peninsula on the south shore of Picatinny Lake after the 1926 Explosion. However, in 1928 an explosion and fire in the 500 Area destroyed two powder blenders and resulted in another relocation of the testing area. In the subsequent rebuilding effort, the testing area was permanently moved to the ridge above the lake.

600 AREA BUILDINGS

Building	Function	Date
600	Change House	1942
602	Black Powder Blender	1935
602A	Magazine	1938
602B	Magazine	1934
603	Dry House	1941
603A	Heater House	1941
603B	Black Powder Dry	1923
603C	Dry House	1923
603D	Inert Storage	1923
603E	Paint Storage	1923
603F	Inert Storage	1923
603G	Keg Opening	1923
603H	Magazine	1944
603I	Magazine	1944
603J	Magazine	1944
604	Ammunition Conditioning Building	1928
604A	Bomb Proof Control House	1928
604B	Detonator Chamber	1931
604C	Sectioning Chamber	1928
604D	Set Back Tower	1928
604E	Wind Tunnel	1942
604F	Bull Pen	1928
604G	Drop Test Tower	1928

Building	Function	Date
605	Screening Building	1924
607	Shell Fragmentation Building	1941
607A	Disassembly Building	1938
609	Black Powder Magazine	1928
610	Propellant Powder Magazine	1928
611	Gun Emplacement	1928
611A	Armor Plate Butt	1929
611B	Fuze Test Tunnel	1929
611C	Live Ammunition Pyrotechnic Storage	1934
613	Ballistic Mortar	1928
617	Field Office and Assembly Building	1928
617A	Constant Temperature Powder Storage	1928
617B	Smokeless Powder Storage	1928
617C	Oil and Grease Storage	1928
617D	Detonator Storage	1928
617E	Oil and Paint Storage	1928
617F	Primer and Fuze Storage	1928
617G	Gun Shed	1938
620	Small Arms Loading	1941
620A	Rate of Detonation Building	1921
620B	Impact Tower - Friction Pendulum	1921
620C	Rocket Range	1943
621	Shell Fragmentation Building	1942
621A	Small Arms Storage	
621B	Receiving Building	1914
623,A-E	Water Tanks	1929/42
625	Bombproof Shelter	1942
629	High Explosive Storage	1942
634	Sand Butt	1930
635	Plate Shed	1943
642B	Battleship Turret	1945

Black Powder Production

Although much of the black powder used by the arsenal was purchased from commercial sources, a small black powder facility was constructed in the woods between the 200 Area and the testing facilities on 20th Avenue. Black powder manufactured at this plant was used as delay rings in grenade fuzes and in the igniters of propellant charges.

Historians do not agree on the origin of black powder and credit for its discovery has been given to the Arabs, the Chinese, and the Hindus. During the 14th century it was used as a propelling charge and in the 15th century graining of black powder began, replacing black powder used in a meal form. Screening and classification of black powder began in France in the 16th century and black powder became the sole propellant charge used in firearms until the 1880's when smokeless powder was introduced. Smokeless powder, (nitrocellulose) was a chemical mixture, unlike black powder which was a mechanical mixture.[1] Nitrocellulose development was encouraged by several basic problems encountered when using black powder as a propellant charge. Black powder deteriorated rapidly when exposed to the weather, was corrosive to gun barrels, produced a large volume of thick black smoke, and often left a residue in the barrel after firing.

Following the successful introduction of nitrocellulose as a propellant, black powder became associated with six basic military uses:

As an ignition charge to ignite a smokeless powder charge.

As the base or expelling charge for shrapnel shells.

As a component of primers and fuzes.

For saluting and blank fire charges.

For time-train rings and combination fuzes.

For mixing with other kinds of propellant powder for use in small arms ammunition.[2]

Black powder was fairly easy to manufacture though it involved a dangerous process. It was composed of a mixture of 75% saltpeter (potassium nitrate), 15% charcoal, and 10% sulphur. Sulphur and charcoal were pulverized in a ball mill and then mixed with pulverized saltpeter. The mixed material was then spread in a wheel mill, which rotated for approximately three hours. To insure uniform consistency, the powder was placed in a horizontal hydraulic press under a pressure of approximately 1,150 psi. The pressed powder was then granulated to the size desired in a corning mill, and screened to remove dust. The final step was finishing, which consisted of polishing and drying the powder.[3] At Picatinny, the black powder section was basically limited to drying powder purchased from others and then blending, glazing and screening the powder to the sizes needed by various facilities within the arsenal.

Testing Within the 600 Area

Testing at the Arsenal encompassed many diverse activities. At each step in the manufacture of both propellant powders and high explosives, samples were taken for testing. This testing was important in helping arsenal personnel understand all the conditions which affect the production and handling of an explosive, including its reaction to temperature, moisture, metals, static electricity, friction, a blow, etc. Many of the tests (e.g. moisture content and purity tests) could be conducted in the area of production, but tests involving the ignition or detonation of explosives were conducted in the 600 Area. These included tests on the explosives, on parts of an explosive device (primers, detonators, etc.) or on the entire device (grenades, bombs, etc.). Testing could be as simple as firing a flint-lock pistol to determine sparking properties of metals or be so complicated as to involve high-speed computer controlled cameras that recorded the action of a bullet being fired from a 50 caliber machine gun.

Tests to determine the characteristics of explosives became highly developed, yet they relied on basically simple equipment. To determine the sensitivity of explosives to impact, a blow or friction, the two most basic experiments were the drop test and the friction pendulum test. The drop test consisted of placing a small amount of explosive in a copper capsule. The capsule was then placed on an anvil and a two kilogram weight dropped on it. This determined the minimum drop at which an explosive will ignite. Explosive tests at Picatinny during the 1920s were used in developing the following data:[4]

Drop Tested Explosives at Picatinny Arsenal

Inches Dropped	Explosives
32	Black Powder Dust
30	Nitroguanidine, Guanidine Picrate

Drop Tested Explosives at Picatinny Arsenal (cont.)

Inches Dropped	Explosives
19	Dinitrotoluene, Dinitrobenzene
18	Ammonium Picrate
17	Dynamite 40%
14	Trojan Grenade Powder
13	TNT, Trinitronaphthalene
12	Amatol
11	Picric Acid
10	Trinitrobenzene
9	Tetryl
8	Nitro Cotton, Smokeless Powder (Pulverized)
7	Hexanitrodiphenylamine, Cyclonite
6	Tetranitroaniline
4	Nitroglycerin
2	Lead Azide, Mercury Fulminate

The friction pendulum test tested the reaction of an explosive to a friction blow. It was capable of dealing with dry or molten explosives, and involved a variety of metal or fiber coverings used on the shoe or base of the pendulum. The explosive sample was placed on the base of the pendulum, and was struck by the shoe of the machine as it swung back and forth across the base. The use of the friction pendulum was limited by the humidity in the building housing the pendulum.

During World War II, there was a great increase in the types of ammunition being produced and every effort was made to systematize component testing before items were sent to the front. The following testing guidelines were paraphrased from the Ordnance School Officers Course.[5]

Ammunition tests were separated into three categories: design tests, inspection tests, and combined tests.

Design Tests: When a new item was requested by a service, engineers were assigned to develop all aspects of the item. For example, with a fuze this included metal components, explosive elements, assembly process, safety precautions to be implemented during assembly and transport, and effectiveness under field conditions. Each aspect was studied and tested during the design and prototype phase. Major design tests for fuzes included:

Tests to determine the safety of a fuze in the bore of a gun.

Tests to determine the safety of the fuze under severe handling conditions in transportation and in the field. These would include drop tests and jolt and jumble tests.

Static tests to ensure that the fuze would explode properly, thus igniting the next element in the explosive train or properly delaying if it was a delay fuze.

Tests to insure that the fuze would arm under "worst case" conditions.

Ballistic tests in the weapon for which it was designed.

Inspection Tests: Once an item passed the design tests it was placed into production. Production inspection tests insured that the specification for assembly were properly met. Some tests, such as gaging of components, could be conducted on the assembly line, while others, such as chemical and ballistic tests, were conducted in special laboratories or in the testing area. From each lot of completed fuzes, a specific number would be sent to the test range for ballistic tests. A large proportion of failures in the ballistic tests would demonstrate poor workmanship, faulty materials or the failure of the manufacturer to comply with the requirements of the fuze specifications.

Combined Testing: Combined testing was done at the time of delivery to determine whether items met specifications and to determine the cause of any problems found in an item. These standardized tests included jolt and jumble tests, drop tests, shell fragmentation tests and armor penetration tests.

The drop test took place in Building 604D, and determined the safety of the component when accidently dropped. It could be used to compare the relative ability of different types of components to withstand impact and it could also be used to simulate the action of setback in a gun in order to develop components that best withstood this type of motion.

The fragmentation test has been described as the most satisfactory test for brisance (the capacity to shatter the medium confining it). The test "enables the explosive to display its strength or brisance, in the actual ammunition component in which it is intended for use....the test involves merely the assembling of the loaded component, and the firing of it statically into a chamber filled with sand."[6] Picatinny's fragmentation test Buildings 607 and 621 tested brisance in sand and sawdust. When constructed, Building 607 had several hundred springs placed in the roof to allow it to react to any explosion.[7] The springs have since been removed, but the building is still in use. In a fragmentation test, a shell or component is placed in sand or sawdust, exploded and the fragments are then screened out, sorted, counted and analyzed.

Besides the actual firing of guns, most of which took place in area 636 (a test range), static tests occurred in the wind tunnel where the shape of the projectile or bomb in relation to wind pressure could be tested.

Building 617 is currently (1983) used as administrative offices while Building 620, with restricted security access, is used for photo testing. Different types of guns, up to the .50 caliber machine guns being tested during the summer of 1983, are fired while high speed cameras capture the action of the bullet in flight. These photographs are studied to determine aerodynamic co-efficients, flow characteristics, causes of dispersion, yaw, etc.

Building 630 serves as the control building for the range test areas. From there activities at the various test ranges are coordinated, ensuring that access to the area is limited during testing periods. With more than a dozen active and inactive ranges in the 600 Area, it is necessary to ensure that no personnel are placed in danger from fragments or shells during testing. (Several times while the HAER team was working in the lower section of the 600 Area, it was required to move indoors while explosive tests were being conducted further along the ridge).

Most of the buildings within the 600 Area test range have served multiple uses. Test buildings not currently in use are in no immediate danger of demolition. Test ranges are discarded and then put back into use as the arsenal's needs fluctuate. In 1983, 600 Area testing facilities were among the busiest at Picatinny Arsenal.

600 Area Footnotes:

1) Lissak, Ormond M. Ordnance and Gunnery. (New York: Wiley and Sons, 1915), pp. 11-12.

2) Army Ordnance. Military Explosives. (Washington: Government Printing Office, 1919), p. 90.

3) Ibid., pp. 91-93.

4) Deck, H.S. "Safety in Explosives Plants." Army Ordnance, Vol. VII, No. 37 (July-August 1926), p. 34.

5) Ordnance School, Picatinny Arsenal. Ammunition, Powder and Explosives Course II, Vol. I, Sect.I-1. (Dover N.J.: Picatinny Arsenal, 1940), pp. 1-13, "Artillery Ammunition General: Ammunition Tests."

6) Picatinny Arsenal Notes. "The Fragmentation Test." Army Ordnance, Vol. V, No. 29 (March-April 1926), p. 760.

7) Hare, Ray M. "Building Safety into an Explosive." Quartermaster Review. (Nov.-Dec. 1930), p. 48.

800 AREA - COMPLETE ROUNDS/MELT LOADING DISTRICT

The Complete Rounds/Melt loading area of Picatinny Arsenal was constructed on the northwest shore of Lake Picatinny beginning in 1930. It was designed following the 1926 Explosion which destroyed the scattered buildings then being used to load shells and bombs. The new facility provided for a smooth flow of materials and explosives through a grouping of four major buildings connected by walkways. Almost all of the explosives used in the 800 Area were manufactured outside of Picatinny Arsenal and shipped in by train. This was especially true during World War II when production was at a maximum.

The 800 Area is located on the north and west shore of Lake Picatinny. The major buildings were constructed along Fidlar Road, with auxiliary buildings located on a small peninsula that extends into the lake. The 700 Area is located to the west of the facility and 900 Area (explosive storage) is located to the east. A sharp ridge rises behind the buildings along Fidlar Road and provides a natural boundary to the 800 Area. The major buildings of the production line have concrete-encased steel frames and eight-inch thick hollow tile walls. The gable roofs are covered with corrugated asbestos-protected metal. Additional buildings are constructed of tile, wood, concrete, and galvanized steel. The major production line was constructed in 1930 while additional buildings were constructed during World War II.

The loading of bombs and shells began at Picatinny Arsenal in 1907. During the first twenty years, this activity was carried on in makeshift facilities around the arsenal (see section on 200 Area). The decision to rebuild the arsenal after the 1926 Explosion allowed for the erection of an isolated shell loading area designed specifically for this task. The complete rounds division was designed as a straight line of buildings and connecting ramps approximately 2,400 feet long. Storage and preliminary service buildings were spaced along the line, and all buildings were placed to provide for a smooth flow of materials while also providing for employee safety in case of an explosion.

The loading of shells and assembly of the complete round was carried on in the 800 Area throughout World War II. The area was reactivated as a full production unit during the Korean Conflict and currently the line is being maintained as a test load facility. This work involves filling shells and bombs for test firing on the arsenal and testing both the explosive filling of the projectile and the shape and composition of the projectile itself. As of 1983 there are no plans to terminate this work.

Building	Function	Date
800	Electric Motor Plant	
802	High Explosive Recovery	1925
803	Inert Storage Magazine	1942
806	Bomb Proof Change House	1930
807	Metal Components - Unloading Cleaning and Inspecting	1930
807B	Vacuum Building	1941
809	Conveyor Drive and Motor House	
810	Explosive Loading	1930
810A	Vacuum Building	1944
813	Explosive Charge Drilling	1930

Building	Function	Date
813B	Flammable Storage	1931
816	Assembly Building	1930
816A	Vacuum Pump House	1944
816B	Compressor Building	1941
820	Complete Rounds Packing	1930
823	Ammonium Nitrate Loading	1930
824	TNT Screening Building	1930
825	TNT Service Magazine	1930

The Complete Rounds Division During World War II

The 800 Area was most active during World War II and the following description of the activities is taken from the Officers Ordnance Course offered at Picatinny during the war.[1] The line was established to load, assemble and pack for shipment various calibers of complete rounds, as well as shells for semi-fixed rounds, separate loaded shells, and fragmentation and demolition bombs. Loaded items included:

Shells from .90 caliber to 240mm howitzer, inclusive.

Fragmentation bombs and demolition bombs from 17 pound to 2,000 pound, inclusive.

Rounds, shell and complete, from .90 caliber to 105mm, inclusive.

Rounds, shrapnel and complete, 75 mm and 3 inch anti-aircraft.

The explosives used in the 800 Area included:

TNT

50/50 Amatol - 50% Ammonium Nitrate and 50% TNT

65/35 Amatol - 65% Ammonium Nitrate and 35% TNT

Trimonite - 88% Picric Acid and 12% Mononitronaphthalene.

Ammanol - 67% TNT, 22% Ammonium Nitrate and 11% Flake Aluminum.

Black Powder.

The method used to load a shell depended upon the item to be loaded, its size and the explosive being used. The major forms of loading used in the 800 Area included:

The casting method - used when the explosives were in a liquid or molten state, such as TNT, 50/50 Amatol, Trimonite and Ammanol.

The pellet method - used principally for filling 100 pound and larger bombs. A combination of molten TNT and TNT pellets were used.

The lob method - developed for loading 65/35 Amatol into large bombs. The consistency of the Amatol mixture was similar to that of thick concrete.

Base charged - used to fill shrapnel with black powder. The powder was poured in funnels and the shrapnel vibrated until it lodged in the space provided.

Although the plant was equipped to crush, dry and screen ammonium nitrate, when possible the arsenal purchased ammonium nitrate with a moisture content below .2%. If necessary, the crusher broke up the ammonium nitrate and fed it into a long cylindrical dryer which rotated and moved the material to a screen used to eliminate lumps.

TNT LOADING

Melting TNT for loading was done either in melting kettles or in continuous melt units. A steam jacketed TNT kettle was partially filled with TNT and, as it melted, additional granular TNT was added until the kettle was filled to capacity, which was usually at about 1200 pounds. Agitators kept the TNT in continuous motion during the melting process. The continuous melt unit, which had a capacity of more than 3,000 pounds per hour, used steam coils to melt the TNT and had a catch pan to hold the molten explosive until it was needed.

When the TNT was melted and ready for use, it was drawn off in galvanized iron cooling tubs equipped with baffles. The cooling was accomplished by a mechanical agitator which kept the entire quantity of molten TNT circulating in the tub until it was considered cool enough to handle. It was then transferred to the pouring room where it was manually stirred, before being poured into black iron or aluminum pails that were equipped with pouring spouts.

Shells or bombs to be filled were placed on lift truck platforms. Pouring funnels were placed in the shell for greater ease of loading and to prevent explosives from lodging in the threads. Shells were not always filled in one pouring, the controlling factor being the size and shape of the cavity. The 3-inch anti-aircraft shell (M42) could be filled in one increment, while the 75mm shell was better filled in two increments. The restricted neck of the 75mm shell caused the TNT to solidify quickly and prevented the TNT from trickling through from the riser to fill the cavities caused by shrinkage of the charge. In all cases it was necessary to break down the crust which formed over each funnel in order to permit the molten material to feed into the shell. TNT recovered from the funnels, pails, or tubs was called clean scrap and could be remelted directly. Floor sweepings and other dirty scrap was saved up for recrystallization, where it would be possible to reclaim the pure TNT.

50/50 Amatol Loading

50/50 Amatol was poured into shells by the same method as molten TNT. It was prepared by preheating the ammonium nitrate in a steam jacketed dough mixer while the TNT was melted in a continuous melt unit. Equal portions of TNT and ammonium nitrate were mixed in a steam jacketed mixing kettle until a homogeneous mix was obtained. Draw-off pipes from the mixing kettle led to the load platforms for loading the large shells and bombs. The draw-off pipes and valves eliminated much of the handling of the explosive and made the mixer immediately ready for the next batch.

Trimonite Loading

An old steam jacketed TNT melter was used for mixing and melting Trimonite. Since the ingredients melted at different temperatures, it was important that the contents be constantly stirred. Steam pressure was kept at 8 to 10 pounds and the temperature was kept between 90 and 100° C. Trimonite could be poured into shells directly form the mixer or from pouring cans. Shells were filled in one pour and a top-off.

Drilling Boostering

The explosive charges in shells and bombs were drilled for booster or fuze cavities. This was done on either vertical or horizontal drilling machines, depending upon the size of the item being drilled. The larger items were drilled on an horizontal machine. Excess explosives were cleaned from the threads with brass, bronze or steel picks depending upon the explosive. A cloth dampened with acetone cleaned any remaining explosive from the threads. Gages ensured that the booster cavity conformed to the proper size.

Complete Rounds Assembly

The complete rounds assembly consisted of putting live primers in the cartridge case, weighing smokeless powder charges and check-weighing, assembling projectiles to cartridge cases, gaging for profile and alignment of the round, inserting fuzes and assembling waterproofed covers. For anti-aircraft ammunition, two discs and a pasteboard tube were assembled on top of the propelling charge in the cartridge case. Primers were assembled in cartridge cases with hand mandrel presses. The primed cartridge cases were transferred to the powder weighing room to receive the powder charge. The loaded cartridge cases were then transferred to the assembling and crimping machine where the shell and cartridge case were assembled together. The assembling machine was equipped to handle rounds from 75mm to 105mm. Each assembled round was gaged in a chamber gage to insure that they would enter the gun chamber freely. The rounds then went to the fuze assembly room where the fuzes were inserted in the rounds and provided with a waterproof cover.

Painting, Stencilling, Packing and Shipping

All rounds were painted with two coats of paint or shell lacquer and complete rounds were packed in fiber containers, boxes or bundle packs. The complete round fiber containers were sealed with colored adhesive tape which indicated the type of round: yellow tape for high explosive rounds, red tape for shrapnel rounds, and blue tape for practice rounds. The tape was stencilled with data to identify the round, the lot number and the date of assembly. Packed boxes were stencilled with this information while bundle packs used identification discs.

The activity of the 800 Area is the simplest of those activities covered in this report. The buildings are few and the machinery simple. A drawing of the layout for the 75mm High Explosive (Recoilless) Operation and Equipment, dated October 28, 1948, records sixteen steps for loading shells, from the screening of the TNT to the inspection and packing of the shells. The most complicated machinery in the entire process was the vertical drill press used to drill the booster cavity, and the Ro-Ball Gyro Screener built by the Day Company used to screen the TNT. The rest of the activities were hand operations using kettles, buckets, brushes, and gages.[2] Larger shells and bombs required more effort to move and load, but this additional activity was more physical than mechanical.

800 Area Footnotes:

1) Ordnance School, Picatinny Arsenal. Ammunition, Powder and Explosives Course II, Vol. 4, Sect. XIV-1 (Dover, N.J.: Picatinny Arsenal, 1940), pp. 1-5, "Visit to Complete Rounds Division at Picatinny Arsenal."

2) Plant Engineering Section, drawing DP-52479 "Record Drawing: Buildings No. 807-808-810-811-824, Layout for 75mm, H.E. (Recoilless) Operation and Equipment." Picatinny Arsenal, October 28, 1948.

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Special Note:

In their typewritten manuscript, "Preliminary Inventory of the Textual Records of the Office of the Chief of Ordnance (Record Groups 156 and 336), Part II, Records of Ordnance Field Installations" (Office of Military Archives, 1965), Evelyn Wade and Garry D. Ryan compiled an inventory of records in the National Archives that concern the operation of U.S. Army arsenals, armories, proving grounds, ordnance depots, etc. This preliminary inventory notes on page 27 that the National Archives apparently retains four folders (Nos. 1323-1326) relating to Picatinny Arsenal. However, the efforts of HAER historians to examine these folders were stymied by notice from National Archives staff that they were "not on shelf." Perhaps in the future these records, as well as others relating to Picatinny Arsenal, will become available to researchers. But as of 1983 they were inaccessible.